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ORIGINAL ARTICLES.

I.—Note on a Devonian Cœlacanth Fish.

By A. Smith Woodward, F.L.S., F.G.S.

STUDENTS of Palæozoic fishes are indebted to Professor A. von Koenen, of Göttingen, for two interesting memoirs on the fragmentary fish-remains of the North German Devonian formations.[1] Owing to their incomplete character, however, the Professor is only able to suggest a provisional interpretation of most of the specimens, and the determination of their true nature must be left for future discoveries.

When visiting Göttingen last year, Professor von Koenen kindly permitted me to examine those of his original specimens which are now in the Geological Museum under his direction. There are many fragments of great interest, including the much discussed Coccosteans and a *Macropetalichthys*, which are better preserved than the others; but there is only one specimen concerning which I am able to make some observations amplifying the description already published.

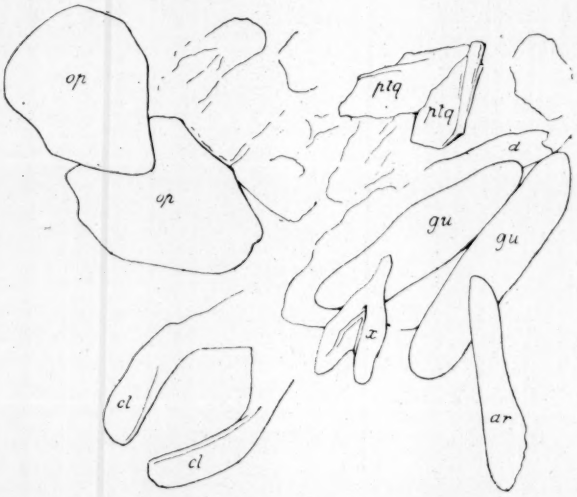
The fossil in question is of considerable importance because, if I am correct, it is the first discovered evidence of the Crossopterygian family Cœlacanthidæ in the Devonian period. The Cœlacanth fishes are known to range, with very little modification, from the base of the Carboniferous to the summit of the Cretaceous. They are completely developed on their first appearance in the Calciferous Sandstones of southern Scotland. Their ancestors must thus be sought in the Devonian rocks, where they have hitherto escaped notice both in Europe and North America.

The specimen is named *Holoptychius Kayseri* by Von Koenen,[2] but he observes that the external ornament of its scales differs so much from that of *Holoptychius* that it may represent a new genus for the definition of which the material is insufficient. The supposed scales, however, seem to me to be characteristic Cœlacanth opercular bones, and several other parts of the Cœlacanth head appear to be identifiable.

[1] A. von Koenen, "Beitrag zur Kenntniss der Placodermen des norddeutschen Oberdevons": Abhandl. k. Ges. Wiss. Göttingen, phys. Cl., vol. xxx (1883), pp. 1–41, pls. i–iv. Also, "Ueber einige Fischreste des norddeutschen und böhmischen Devons": ibid., vol. xl (1895), pp. 1–37, pls. i–v.

[2] Loc. cit., 1895, p. 28, pl. ii, fig. 1.

An explanatory outline sketch of this fossil, of the natural size, is given in the accompanying figure. It is based upon Von Koenen's beautiful drawing. In the left upper corner are the two opercula (*op.*), slightly overlapping and exposing their outer ornamented



Cœlacanthus Kayseri (Von Koenen); outline of associated head-bones, etc. Upper Devonian: Müllenborn, Gerolstein. For explanation of lettering see text.

face. They taper rapidly in their lower half, and their maximum width is about three-quarters the measure of their maximum depth. The ornamental ridges are frequently interrupted, almost all directed horizontally, and somewhat coarser behind than in front. Below these plates are the two clavicles (*cl.*), rightly identified by Von Koenen. Their lower end is obscured, but the upper portion has the typical Cœlacanth form and is marked by a few transverse ridges. Another characteristic fragment of bone (*x.*) lies to the right of the expanded lower end of the clavicles. This is the hinder part of the supposed copula of the branchial arches. The two gular plates (*gu.*) are distinct, each slightly more than four times as long as broad, and ornamented with fine concentric ridges, which are not subdivided into tubercles. These plates seem to be gently rounded at either end, not tapering in front more than behind. Remains of the mandible (*d.*) occur on each side of the gular plates, and the characteristic articulo-angular bone (*ar.*) of the left side is displaced so as to show its form and proportions. It is ornamented with fine ridges which are mainly directed longitudinally. Upwards and forwards the two pterygo-quadrate elements (*ptq.*) seem to be crushed together; but these and other fragments are too imperfect for description.

Sufficient characteristic bones are thus preserved to indicate that the fossil in question represents a typical Cœlacanth head. The

only difficulty arises in reference to its generic determination. It will be best to place it provisionally in the genus *Cœlacanthus*, from which the parts described differ in no essential respect; while the minor characters of form and ornamentation just enumerated readily separate it from all known species.[1] It must thus be recorded for the present as *Cœlacanthus Kayseri*. The only well-known Lower Carboniferous species, *C. Huxleyi*,[2] differs very considerably from this form in the feebleness of its ornamentation; but a detached gular plate from the Lower Carboniferous Limestone of Armagh exhibits a nearer approach to it.[3]

The type-specimen of *Cœlacanthus Kayseri* was found by Dr. von Koenen in the lower part of the Upper Devonian at Müllenborn, near Gerolstein; and it is interesting to add that in the same formation and locality he met with a second small fossil, which he provisionally regards as a scale of *Rhizodopsis*,[4] another Carboniferous genus. I am, however, convinced that this supposed scale is much too thick and bony to be referred to the latter fish, and its systematic determination must remain as entirely problematical.

II.—Notes on some Lower Tertiary Shells from Egypt.

By R. Bullen Newton, F.G.S.

(PLATES XIX AND XX.)

THE Tertiary shells referred to in this paper constitute a portion of the Egyptian collection of fossils sent to the British Museum for description by Capt. H. G. Lyons, R.E., F.G.S., Director of the Geological Survey of Egypt.

Among the principal writers on this subject may be mentioned the names of Bellardi, Fraas, and Mayer-Eymar; the contributions of the last-mentioned having mostly appeared in the *Journal de Conchyliologie* (Paris), *Vierteljahrsschrift Naturforschenden Gesellschaft Zürich*, and in Zittel's memoir on Egypt contained in the *Palaeontographica* for 1883. For the latest information on the distribution of the Tertiary rocks of Egypt we must consult Captain Lyons' monograph in the Quarterly Journal of the Geological Society of London, vol. L (1894), "On the Stratigraphy and Physiography of the Libyan Desert of Egypt."

The specimens have been obtained from several localities, chiefly in the neighbourhood of the Nile, such as Minyeh, Esna, Assiout, Wadi Faregh, etc.; and the various horizons represented include—

(?) Oligocene.
Middle Eocene (Mokattam Series).
Lower Eocene (Libyan Series).

[1] A synopsis is given in A. S. Woodward's "Catalogue of Fossil Fishes in the British Museum," pt. ii (1891), pp. 399–408.

[2] R. H. Traquair, Trans. Roy. Soc. Edin., vol. xxx (1881), p. 20, pl. i, figs. 1–4; A. S. Woodward, op. cit., p. 407, pl. xiv, fig. 1.

[3] J. W. Davis, Trans. Roy. Dublin Soc. [2], vol. i (1883), p. 524, pl. lxiii, fig. 12.

[4] A. von Koenen, loc. cit., 1895, p. 29, pl. ii, fig. 2 (*Rhizodopsis dispersa*).

MOLLUSCA: GASTEROPODA.

Genus MITRA, Chemnitz.

Conchylien-Cabinet, vol. iv (1780), p. 205, pl. cxlvii, fig. 1,360.

TYPE.—*Voluta episcopalis*, Linnæus.

MITRA TURRICULATA, Schafhäutl. (Pl. XIX, Fig. 1.)

Mitra turriculata, Schafhäutl, "Süd-Bayerns Leth. Geogn. Kressenberg," 1863, p. 209, pl. lii, fig. 5; Fraas, "Aus dem Orient," 1867, p. 149.

DESCRIPTION.—Species narrow, elongate, fusiform; whorls deep, flattened, turriculate, and canaliculated at the suture; aperture elongate and narrow; columella slightly oblique.

DIMENSIONS.

Largest specimen—Length	... ...	55 mm.
Diameter	... ...	23 mm.

REMARKS.—The Egyptian specimens referred to this species appear to be in every way analogous to the type from the Kressenberg Eocene, examples of which in the British Museum have been available for comparison. Like the type they are mere casts, showing rather long and prominent turriculate spires with depressed whorls and a sutural canaliculation. The matrix is a light yellowish foraminiferal limestone.

HORIZON.—Middle Eocene (Mokattam Series).

DISTRIBUTION.—Kressenberg. Egypt: Mokattam (Fraas); Minyeh. Coll. Geol. Surv. Egypt (No. 848, Box No. 50*c*).

Genus HIPPOCHRENES, Montfort.

Conch. Syst., vol. ii (1810), pp. 522, 523.

TYPE.—*Strombus amplus*, Brander.

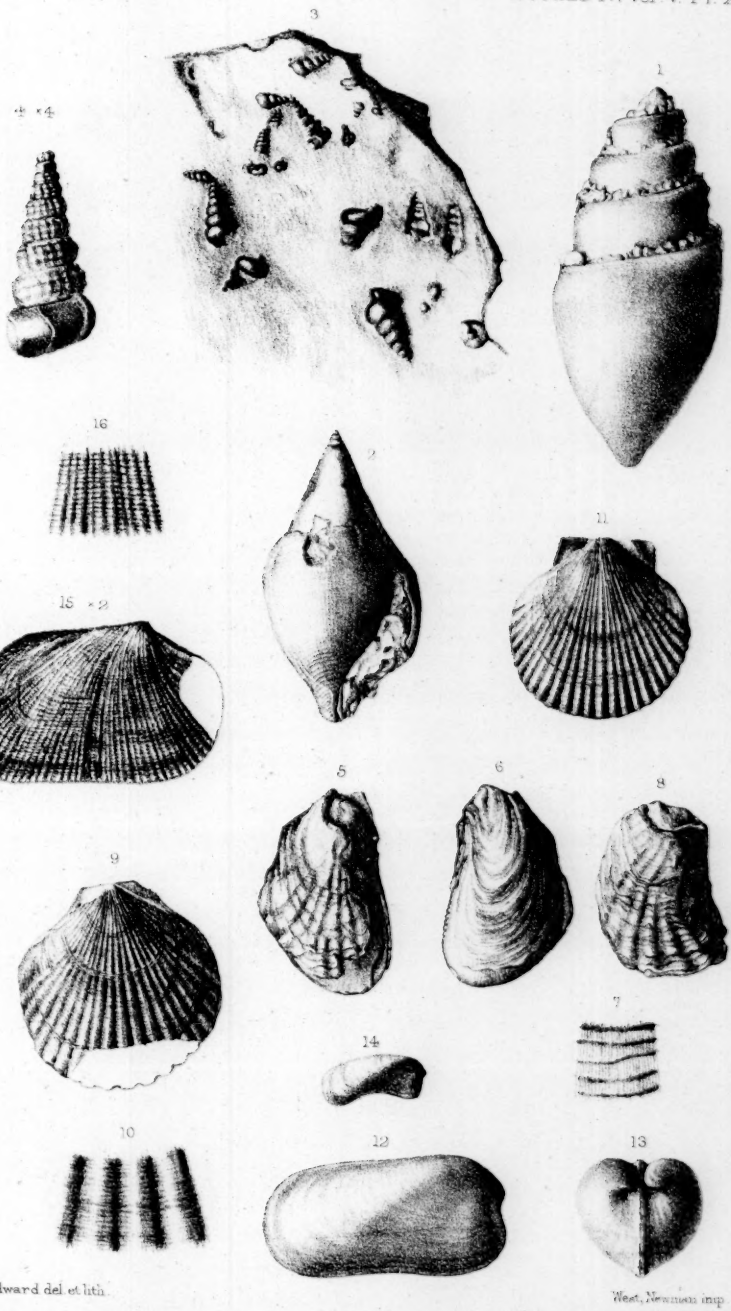
HIPPOCHRENES, sp. (Pl. XIX, Fig. 2.)

REMARKS.—This genus is represented by four specimens in a somewhat worn condition, without aliform expansions or complete anterior canals. An attachment line is, however, present on the side of the spire, which denotes the position either of a former decumbent canal, as in *H. columbarius*, or a large expansion such as characterizes *H. amplus*. The first-named species, already recorded from Egypt by Bellardi,[1] is a perfectly smooth form without any spiral striations. A spiral sculpture is observable on the present Egyptian specimens, the lines being almost horizontal, though becoming more oblique and closer together at the anterior prolongation. Such ornamentation would suggest affinities with *H. amplus*, but in the absence of other details it is not desirable to attempt a specific determination of remains so incomplete. They are of fusiform shape, having a short conical pointed spire and an inflated body-whorl.

DIMENSIONS.

Chief specimen—Length	... ...	40 mm.
Diameter	... ...	22 mm.

[1] "Cat. Foss. Nummulitici d'Egitto": Mem. R. Ac. Sci. Torino, 1854, p. 178.



G.M. Woodward del. et lith.

West, Newman imp.

Egyptian Lower Tertiary Shells

Horizon.—Middle Eocene (Mokattam Series).

Distribution.—Egypt: Minyeh. Coll. Geol. Surv. Egypt (Nos. 844, 848; Box Nos. 12* *c*, 50*c*).

Genus POTAMIDES, Brongniart.

Annales Muséum Paris, vol. xv (1810), p. 367, pl. xxii, fig. 3.

Type.—*P. Lamarcki*, Brongniart.

Potamides (allied to) perditus (Bayan). (Pl. XIX, Figs. 3, 4.)

Cerithium perditum, Bayan: "Études Foss. Nouveaux," fasc. i (1870), p. 41 (= *Cerithium Lamarcki*, Deshayes *non* Brongniart, and *C. deperditum*, Deshayes *non* Michelotti).

Description. — Shell with an elongate, turreted, and acuminate spire; whorls numerous, convex, deeply sutured, spirally striate, and longitudinally ribbed; terminal whorl large and basally depressed; aperture round; labrum sinuated; canal short.

Dimensions.

Length	12 mm.
Spiral angle	17°.

Remarks.—A number of silicified casts of a small *Cerithium*-like shell are determined as being allied to *Potamides perditus*, a well-known Paris Basin univalve. The specimens, well exposed on the surfaces of a lenticular chert-bed measuring about an inch in thickness, have from ten to twelve whorls separated by a deep suture, and a prominently sinuated labrum. Sculpture has mostly disappeared, but a few examples exhibit two spiral lines in the centre of the whorl, crossed by longitudinal costæ. The main difference between this form and the typical species appears to be its very much smaller size, so that a relationship so close would suggest an Eocene age for this particular chert-deposit, although the Egyptian Survey officers are inclined to regard it as belonging to a somewhat later period.[1]

Horizon.—Eocene or Oligocene (?).

Distribution.—Egypt: Wadi Natrum, lake deposits, north-west of Cairo. Coll. Geol. Surv. Egypt (No. 633, Box No. 37*a*).

Limnæa, Melanopsis, etc.

Remarks. — Numerous casts of *Limnæa*, *Melanopsis*, *Potamaclis*, *Bithynia*, etc., are observable in a highly saliferous, white, chalky limestone[2] of variable hardness. In its fauna and general lithological features this matrix bears a curious resemblance to the Headon Hill limestone of the Isle of Wight, and even the species, judging from the imperfect condition of the specimens, show a similar facies in both. The molluscan remains are, however, so badly preserved that they do not lend themselves to either accurate identification or description, making it difficult to refer them to any special horizon, although they may temporarily be regarded as doubtfully of Oligocene age.

[1] Information supplied to the writer by Dr. Hume in August, 1898.

[2] Mr. G. T. Prior, of the British Museum, informs me that this matrix is not a dolomite, although referred to as such on the manuscript lists accompanying the collection.

Horizon.—Oligocene ?

Distribution.—Egypt: Wadi Natrum. Coll. Geol. Surv. Egypt (No. 635; Box Nos. 44*a*, 45*a*, 46*a*).

Conus and Voluta.

Remarks.—The collection contains some worn and fragmentary specimens of *Conus* and *Voluta*, which are unfortunately not specifically determinable; they occur in a light foraminiferal limestone associated with *Mitra turriculata* and *Hippochrenes*, sp.

Horizon.—Middle Eocene (Mokattam Series).

Distribution.—Egypt: Minyeh. Coll. Geol. Surv. Egypt (No. 844, Box No. 12*c*).

[Gasteropod Casts—indeterminable.]

Remarks.—Two fragments of a light-coloured matrix containing casts of a small univalve shell without definition.

Horizon.—Eocene (?).

Distribution.—Egypt: Wadi Natrum. Coll. Geol. Surv. Egypt (No. 638, Box No. 49*a*).

Gasteropods and Lamellibranchs—indeterminable.

Remarks.—A number of diminutive mollusca belonging to the genera *Potamaclis, Corbula*, etc., mostly casts and impressions, are contained in a fawn-coloured calcareous sandstone, which is made up of innumerable rounded fragments of quartz, agglutinated by a siliceous cement. Professor Mayer-Eymar[1] has described a somewhat similar sandstone from the neighbourhood of Cairo, in which he has recognized eighteen species of shells under the genera *Astarte, Cyrena, Tellina, Corbula, Hydrobia, Melanopsis, Potamaclis*, etc., regarding them as of Tongrian age.

Horizon.—Oligocene ?

Distribution.—Egypt: Wadi Faregh, south-east of Wadi Natrum. Coll. Geol. Surv. Egypt (No. 634, Box Nos. 38*a* to 43*a*).

MOLLUSCA: LAMELLIBRANCHIATA.

Genus OSTREA, Linnæus.

Systema Naturæ, 1758, ed. x, p. 696.

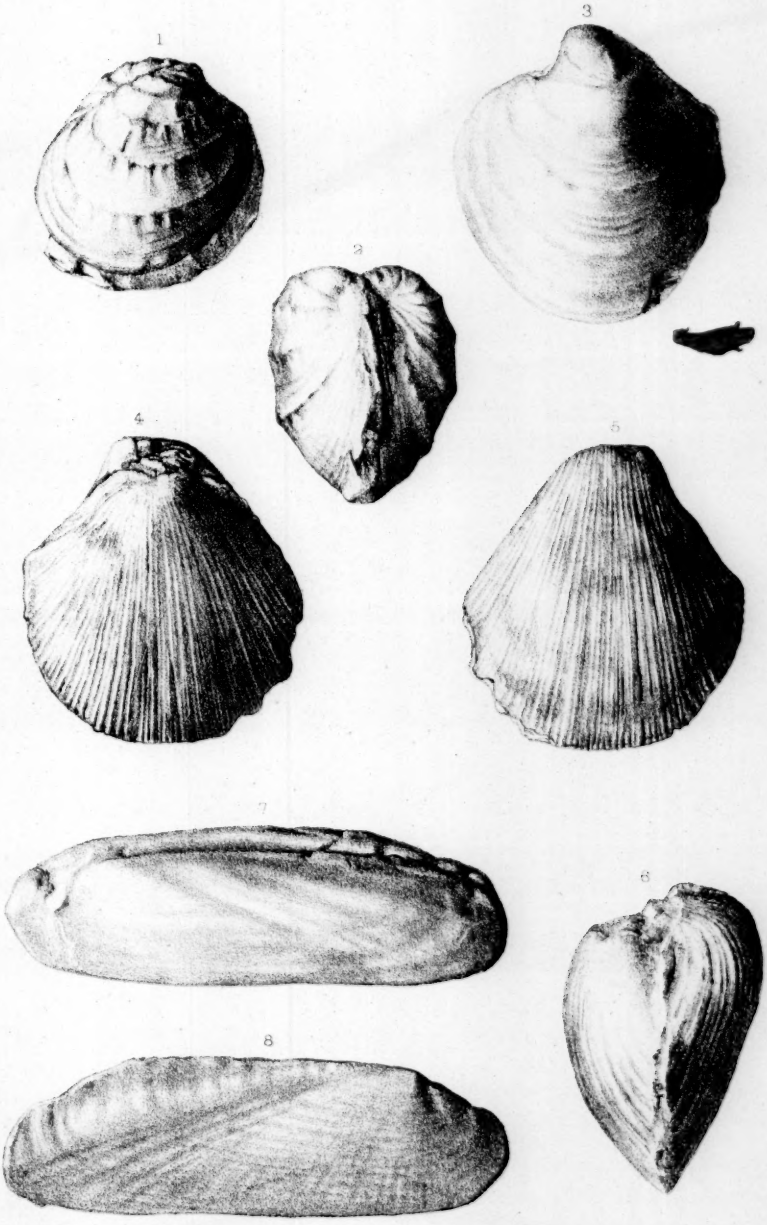
Type.—*O. edulis*, Linnæus.

Ostrea aviola, Mayer-Eymar. (Pl. XIX, Figs. 5–8.)

Ostrea aviola, Mayer-Eymar, "Diagnoses Ostrearum novarum ex agris Ægyptiæ": Viert. Nat. Ges. Zürich, vol. xxxiv (1889), p. 297 (not figured).

Description.— *O. testa parva, satis variabili, modo ovata, modo ovato-rotundata, modo subquadrata, leviter obliqua, modo tenuiuscula,*

[1] "Zur Geologie Egyptens": Viert. Nat. Ges. Zürich, vol. xxxi (1886), p. 261. "Ueber das Tongrian von Cairo (Egypten)": ibid., vol. xxxiv (1889), p. 195 and plate of fossils. "Le Ligurien et le Tongrien en Egypte": Bull. Soc. Géol. France, ser. III, vol. xxi (1893), p. 31.



G. M. Woodward del. et lith. West, Newman imp.

Egyptian Lower Tertiary Shells.

modo solidula; valva inferiore plus minusve convexa, plerumque umbone adnata, costis paucis, crassis, depresso-fornicatis, inæqualibus, postice minoribus, raro dichotomis, a lamellis concentricis, plus minusve distantibus, nodoso-spinosis; umbone parvo, plus minusve obtuso, leviter incurvo; cardine brevi, obliquo, canali lato; marginibus superne scrobiculato-striatis; cicatricula musculi subtriangulari, leviter obliqua; valva superiore minore, plano-convexa, leviter lamellosa; cardine lato, plano; marginibus superne crenulatis, inferne leviter denticulatis. (Mayer-Eymar.)

Remarks.—The diagnosis here given *in extenso* refers to a small Egyptian oyster which apparently has never been figured, but which the author states is related to *O. Flemingi* of D'Archiac and Haime,[1] from the Nummulitic formation of India. Some specimens in the Egyptian Collection appear to belong to this species. They are smaller and narrower than the Indian species (*O. Flemingi*), with a lower valve bearing fluted or lamellose costæ and an upper valve marked with fine imbricating concentric laminæ, besides being crowded with minute vertical striations. The specimens are of one nearly uniform size, and although no interiors are seen, the valves being in contact, marginal denticulations are clearly displayed. From the number of examples sent, this species must be fairly abundant; they are slightly encrusted with 'Beekite.'

Dimensions.

Height	28 mm.
Length	17 ,,
Diameter of united valves	14 ,,

Horizons.—Middle Eocene (Mokattam Series); Lower Eocene (Libyan Series).

Distribution.—Egypt: El Guss Abu Said; Nokba; Oasis Farafrah; Mons Medine Abu, near Thebes; Mokattam—(Mayer-Eymar); left bank of Nile about ten kilometres north of Esna. Coll. Geol. Surv. Egypt (No. 1,001, Box No. 41*c*).

Genus PECTEN, O. F. Müller.

Zool. Danicæ Prod., 1776, p. xxxi.

Type.—*Ostrea maxima*, Linnæus.

Pecten Mayer-Eymari, sp. nov. (Pl. XIX, Figs. 9–11.)

Description.—Shell lenticular, circular, fan-shaped, costated; costæ 20, subrotund or carinated, obsolete laterally; grooves well channelled; surface ornamented with fine concentric lines of growth; auricles subequal.

Dimensions.

Height	27 mm.
Length	27 mm.

This species bears a true Eocene facies, being related to *P. reconditus*, Solander, and *P. carinatus* of J. de C. Sowerby. It differs from the former in the absence of any grooval squamulose ornamentation and in the possession of almost smooth sides; from the

[1] Desc. Anim. Foss. Nummulitique l'Inde, vol. ii (1854), p. 275, pl. xxiii, figs. 14, 15.

latter it is separated by its rounder and more fan-shaped contour, the closer arrangement of its costæ and consequently narrower grooves. In the adult stage the summits of the ribs show a decided angularity, suggesting affinities with *P. carinatus*. On the early stages of the ribs a minute nodulose character is present, somewhat resembling *P. solariolum* of Mayer-Eymar[1] from the Egyptian Eocenes.

Remarks.—The shell appears to be fairly common, occurring in a soft cream-coloured chalky rock as well as in a reddish-brown matrix of a marly character. The specimens are, however, rarely well preserved, being chiefly impressions; associated with them are some obscure plant remains, a small *Arca* (*A. Esnaensis*, n.sp.), and other mollusca of a fragmentary nature. Professor Mayer-Eymar's name is associated with this shell in acknowledgement of his important researches on the geology and palæontology of Egypt.

Horizon.—Lower Eocene (Libyan Series).

Distribution.—Egypt: Hills west of Jebel Zait, western shore of the Gulf of Suez (28*a* to 30*a*); and right bank of the river Nile opposite Esna (49*c*). Coll. Geol. Surv. Egypt (No. 628, Box Nos. 28*a* to 30*a*; No. 1,003, Box No. 49*c*).

Genus SPONDYLUS, Linnæus.

Systema Naturæ, 1758, ed. x, p. 690.

Type.—*S. gæderopus*, Linnæus.

Spondylus Ægyptiacus, sp. nov. (Pl. XX, Figs. 4–6.)

Description.—Shell subovate, inequivalve, nearly equilateral, inflated at the summit; lower or right valve the largest and most convex, with usually a depressed, adherent surface at the umbo; valves ornamented with numerous fine radial ribs (between fifty and sixty), which are rounded or acute according to preservation, smooth, and separated by simple grooves without striations: sculpture more or less zoned, with from eight to ten more distinctive ribs than the rest; ribs apparently without spines; internal characters not seen.

Dimensions (with valves united).

Height	...	...	...	...	...	43 mm.
Length	...	...	...	...	...	38 ,,
Diameter	...	...	...	...	...	27 ,,

Remarks.—According to the researches of Bellardi[2] and Zittel[3] two species of *Spondylus* have been recognized from the Egyptian Eocenes, viz., *S. rarispina*, Deshayes, and *S. Rouaulti*, D'Archiac, a form originally described from the Nummulitic of India. Both, however, differ from the present shell, not only in outline, but in their primary ribs being furnished with conspicuous spines; *S. Rouaulti*, in addition, exhibiting transverse striations between the

[1] Journ. Conchyliologie, 1888, pl. xiv, fig. 5, p. 328.
[2] Bull. Soc. Géol. France, 1851, ser. II, vol. viii, p. 261.
[3] Palaeontographica, 1883, vol. iii, p. cvii.

costal grooves. The absence of spines, also, separates the new form from *S. multistriatus* of Deshayes, and from Schafhäutl's[1] Kressenberg species, *S. astragalus*.

This species is represented by six specimens, the largest (a lower valve) measuring 44 × 41 millimetres, the remainder being of more uniform size and having united valves. They are in a fair state of preservation, without spinous attachments to the ribs, nor is there any indication of striations between the grooves. The matrix is a white chalky foraminiferal (*Operculina*, etc.) limestone and similar to that containing *Chama late-costata*.

Horizon.—Lower Eocene (Libyan Series).

Distribution.—Egypt: near Assiout. Coll. Geol. Surv. Egypt (No. 630, Box No. 33*a*).

Genus CHAMA, Linnæus.

Systema Naturæ, 1758, ed. x, p. 691.

Type.—*C. lazarus*, Linnæus.

Chama late-costata, Bellardi. (Pl. XX, Figs. 1–3.)

Chama late-costata and *C. latilamellata*, Bellardi, "Cat. Rais. Foss. Nummulitiques Nice": Mém. Soc. Géol. France, ser. II, vol. iv (1851), p. 254, pl. xx, fig. 12.

Description.—*Testa ovato-rotundata, subequivalvis, lævi, concentrice costata; costis lamellosis, postice subimbricatis, distantibus dente cardinali recurvo, crasso, lævi; umbonibus recurvis, subspiratis* (Bellardi). This is the original diagnosis of a shell which is mainly distinguished from other *Chamæ* by the widely distant concentric ribs ornamenting its valves. The upper valve is more sculptured than the other, possessing numerous pillar-like, radial costæ in the concentric spaces, thereby connecting the species very closely with *C. calcarata*, Lamarck, from the Paris Basin Eocenes. Although somewhat worn, the Egyptian specimens show all these details of structure, besides preserving some faint indications of concentric striæ between the primary costæ of the lower valve. No interiors are seen.

Dimensions.

Largest lower valve—	Height	... ...	42 mm.
	Length	... ...	37 ,,
	Diameter	... ...	15 ,, (about).

Remarks.—Found in a white chalky foraminiferal limestone stained with iron peroxide, and accompanied by a *Spondylus*. The smallest and most perfect specimen has both its valves united.

Horizon.—Lower Eocene (Libyan Series).

Distribution.—Environs of Nice (Bellardi); Pyrenees (D'Archiac); Spain (Mallada); Egypt, near Assiout. Coll. Geol. Surv. Egypt (No. 636, Box No. 47*a*).

[1] Süd-Bayerns Lethæa Geognostica der Kressenberg, etc., 1863, p. 148, pl. 65*b*, fig. 13.

Genus ARCA, Linnæus.

Systema Naturæ, 1758, ed. x, p. 693.

Type.—*A. Noæ*, Linnæus.

Arca Esnaensis, sp. nov. (Pl. XIX, Figs. 15, 16.)

Description. — Shell small, inequilateral, moderately convex, transversely oval; surface ornamented with a close cancellation formed by a series of radial, fimbriate costæ, crossed by concentric striæ, which at the junctions assume a noded or beaded appearance; valve slightly depressed in the centre; carination oblique and dorsally acute; margins more or less rounded; slight mesial depression present.

Dimensions.

Height	...	...	...	...	...	11 mm.
Length	...	...	...	...	...	18 mm. (about).

Remarks.—This description is drawn up from a single right valve, embedded in the same matrix as contains *Pecten Mayer-Eymari*. The specimen has a highly ornamented test, with rays of equal thickness and a uniform distance from each other. One of the margins is round, the other imperfect. It is most closely related to *Arca appendiculata* of J. Sowerby, especially in its decussated sculpture, and is doubtless a good Eocene form of the genus. From its rarity in Egyptian rocks the specimen is considered of sufficient importance to merit a notice under the present new name.

Horizon.—Lower Eocene (Libyan Series).

Distribution.—Egypt: right bank of river Nile opposite Esna. Coll. Geol. Surv. Egypt (No. 1,003, Box No. 49* *c*).

Genus MACROSOLEN, Mayer-Eymar.

Palaeontographica, vol. xxx (1883), p. 116.

Type.—*Sanguinolaria Hollowaysi*, J. Sowerby.

Macrosolen Hollowaysi, J. Sowerby. (Pl. XX, Figs. 7, 8.)

Sanguinolaria Hollowaysi, J. Sowerby: Mineral Conchology, vol. ii (1817), p. 133, pl. clix.

Solen uniradiatus, Bellardi, "Cat. Foss. Numm. Egitto": Mem. R. Ac. Sci. Torino, ser. II, vol. xv (1854), p. 16, pl. ii, fig. 5.

Sanguinolaria (*Macrosolen*) *Hollowaysi*, Mayer-Eymar in Zittel: Palaeontographica, vol. xxx (1883), p. cxvi.

Gari (?) *Hollowaysi*, R. B. Newton: Syst. List Edwards Coll. Brit. Mus., 1891, p. 76.

Description.—This species was originally described as "depressed, transversely elongate, ovate, and striated; anterior [should be posterior] side gradually expanded; posterior [should be anterior] side very small."

It is a well-marked shell, and easily distinguished by its transversely elongate shape, the very anterior position of the umbones, and the oblique furrow extending from the umbonal area to the posterior margin. The hinge consists of two diverging teeth in

each valve; the ligament being supported by a prominent elongate nymph or fulcrum.

Some excellent casts of this species are in the Egyptian Collection, though of course showing no dental characters such as are preserved in the beautiful examples from the Bracklesham Beds of England.

DIMENSIONS.

Height	...	...	...	...	...	20 mm.
Length	...	...	...	...	...	68 ,,
Diameter	...	...	...	...	...	13 ,,

REMARKS.—A very pronounced pallial sinus and some important dental differences separate this genus from *Cultellus*. It appears to be rather closely related to *Gari* (= *Psammobia*) in the deep sinus and character of the teeth, though possessing more inequilateral valves. Such differences as are here indicated make it convenient to adopt *Macrosolen*, proposed by Professor Mayer-Eymar in 1883 for the reception of *S. Hollowaysi*. Professor Mayer-Eymar has kindly furnished the writer with the following note on this subject: "The genus *Macrosolen* was indeed proposed by me for Sowerby's *Sanguinolaria Hollowaysi*, and published for the first time in the work of Mr. Zittel on Egypt, 1883. I have never given a description of this genus, but I think it may be a good one, taking rank in the family of the Solenidæ near *Cultellus* and *Solen*, having the same mode of increasing beaks and the same long ligament. In Egypt the species is very common, both in the Lower and Upper Parisian or Middle Eocene. I know of no other species of *Macrosolen*."

The shell figured and described by Bellardi from Egypt as *Solen uniradiatus* is doubtless the same as Sowerby's species; its name is therefore regarded here as a synonym of the older form.

HORIZON.—Middle Eocene (Mokattam Series).

DISTRIBUTION.—England: Bracklesham Bay; Stubbington; White Cliff Bay. Egypt: between Guiset and Fayoum; Abu Zabel. Coll. Geol. Surv. Egypt (No. 644, Box No. 60*a*).

[CAST OF A LUCINIFORM SHELL.]

REMARKS.—Cast of a small Luciniform shell showing rather prominent concentric sulcations: indeterminable.

HORIZON.—Eocene?

DISTRIBUTION.—Egypt: Wadi Natrum. Coll. Geol. Surv. Egypt (No. 639, Box No. 50*a*).

Genus LITHOPHAGUS, Megerle von Mühlfeld.

"Entwurf Syst. Schalthiergehäuse": Mag. Ges. Nat. Freund. Berlin, vol. v (1811), p. 69.

TYPE.—*Mytilus lithophagus*, Linnæus.

SYNONYM.—*Lithodomus*, Cuvier, 1817.

LITHOPHAGUS CORDATUS, Lamarck. (Pl. XIX, Figs. 12–14.)

Modiola cordata, Lamarck: Annales Mus. Hist. Nat., vol. ix (1807), pl. xviii, fig. 2; Hist. Nat. Anim. sans Vert., vol. vi (1819), pt. 1, p. 117. Deshayes: Desc. Coq. Foss. Paris, vol. i (1830), p. 268, pl. xxxix, figs. 17–19.

Lithodomus cordatus ? Bellardi, "Cat. Foss. Numm. Egitto": Mem. R. Ac. Sci. Torino, ser. II, vol. xv (1854), p. 193.

Mytilus subobtusus, D'Archiac: Desc. Anim. Foss. Numm. Inde, vol. ii (1854), p. 268, pl. xxiii, fig. 13.

Mytilus (*Lithodomus*) *cordatus*, Mayer-Eymar: Viert. Nat. Ges. Zürich, vol. xxxvi (1891), p. 174.

DESCRIPTION.—*Testa elongata, cylindracea, arcuata, tumida, lævigata; umbonibus inflatis, antice inflexis, cordatis, subspiratis, prominentibus.* (Deshayes.)

This diagnosis of Lamarck's shell is reproduced from Deshayes' work in preference to the original as being rather more complete. The present examples of the species consist of several excellent casts, the valves of which are attached; some coral structure is retained at the anterior end of the largest specimen, into which the mollusc had burrowed. The species is easily distinguishable from other fossil forms by the strongly modioliform and tumid character of the valves, together with the terminal incurved beaks and its generally striking resemblance to *Lithophagus cinnamominus*, Chemnitz, of recent seas. The Indian species, *M. subobtusus*, agrees in all essential details with *L. cordatus*, and it has therefore been united here, this being in accordance with the views of Professor Mayer-Eymar.

DIMENSIONS.

	Largest.	Smallest.
Height	40	10 mm.
Length	20	5 ,,
Diameter	22	6 ,,

REMARKS.—Bellardi appears to have made the first record of this shell from Egypt.

HORIZON.—Lower Eocene (Libyan Series).

DISTRIBUTION.—Paris Basin; Germany; Belgium; Alps; India; Egypt, Abu Zabel (60*a*) and fifteen kilometres west of Esna (51*c*). Coll. Geol. Surv. Egypt (No. 645, Box No. 60*a*; No. 240, Box No. 51*c*).

EXPLANATION OF PLATE XIX.

MITRA TURRICULATA, Schafhäutl.

Middle Eocene (Mokattam Series): Minyeh.

FIG. 1. Dorsal view, with typical spire: Foraminifera are seen at the suture.

HIPPOCHRENES, sp.

Middle Eocene (Mokattam Series): Minyeh.

FIG. 2. Ventral aspect, showing obscure spiral ornamentation.

POTAMIDES (allied to) PERDITUS, Bayan.

? Oligocene: Wadi Natrum.

FIG. 3. Portion of a small chert-slab with scattered examples of the shells.

FIG. 4. Magnified view of a specimen, showing sculpture (× 4).

OSTREA AVIOLA, Mayer-Eymar.

Lower Eocene (Libyan Series): about ten kilometres north of Esna.

FIG. 5. External view of lower valve } same specimen.
FIG. 6. ,, ,, upper valve }

FIG. 7. Surface magnification of upper valve, showing striations.

FIG. 8. Another lower valve, with adherent surface at the summit.

PECTEN MAYER-EYMARI, sp. nov.

Lower Eocene (Libyan Series): opposite Esna.

FIG. 9. External view of one of the valves.
FIG. 10. Surface magnification of same, showing sculpture.

Lower Eocene (Libyan Series): Hills west of Jebel Zait.

FIG. 11. External aspect of specimen, with fairly perfect auricles.

LITHOPHAGUS CORDATUS, Lamarck.

Lower Eocene (Libyan Series): Abu Zabel.

FIG. 12. View of adult form, exhibiting the right valve.
FIG. 13. Anterior aspect of same, showing the beaks.
FIG. 14. A young specimen.

ARCA ESNAENSIS, sp. nov.

Lower Eocene (Libyan Series): opposite Esna.

Fig. 15. External view of right valve, magnified twice.
FIG. 16. Magnified view of surface, showing sculpture.

EXPLANATION OF PLATE XX.

CHAMA LATE-COSTATA, Bellardi.

Lower Eocene (Libyan Series): near Assiout.

FIG. 1. Outer view, showing the upper or more sculptured valve.
FIG. 2. Posterior aspect of same specimen.
FIG. 3. External view of the largest lower valve.

SPONDYLUS ÆGYPTIACUS, sp. nov.

Lower Eocene (Libyan Series): near Assiout.

FIG. 4. Front aspect of chief specimen.
FIG. 5. Back ,, ,, ,,
FIG. 6. Profile ,, ,, ,,

MACROSOLEN HOLLOWAYSI, J. Sowerby.

Middle Eocene (Mokattam Series): between Guiset and Fayoum.

FIG. 7. Outer view, exhibiting the left and part of the right valves
FIG. 8. ,, ,, ,, right valve } same specimen.

(Except where otherwise mentioned, the figures on both plates are of the natural size.)

III. — ON A DEFORMED EXAMPLE OF *HOPLITES TUBERCULATUS*, J. SOWERBY, SP., FROM THE GAULT OF FOLKESTONE.

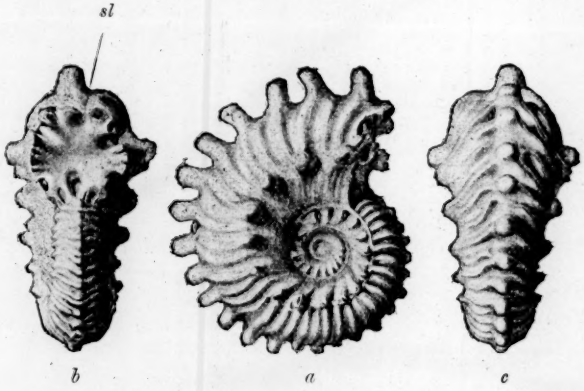
By G. C. CRICK, F.G.S.,
Of the British Museum (Natural History).

THERE has recently been presented[1] to the British Museum collection an Ammonite from the Gault of Folkestone that seems to be worthy of a short note. It is represented in the accompanying figures. At first sight it appears to be a new species. The shell is nearly complete and exceedingly well preserved; there has evidently been another half whorl to the specimen (see Fig. *a*), but this, which apparently constituted the body-chamber, has been broken away, leaving at the anterior end of the specimen the surface of the last septum. The sculpture of the sides instantly reminds one of the ornaments of the well-known *Hoplites tuberculatus*, J. Sowerby,[2] sp., but in that species the middle of

[1] By Mr. C. Coles.

[2] J. Sowerby, Min. Conch., vol. iv (1821), p. 4, pl. cccx, figs. 1–3. The originals of figs. 1 and 3 are in the British Museum collection.

the ventral area is occupied by a well-marked and sharply-defined channel with a row of tubercles on each side, the tubercles on one side usually alternating with those on the opposite side, whereas in the present specimen the median part of the periphery (see



Deformed example of *Hoplites tuberculatus*, J. Sowerby, sp., from the Gault, Folkestone. *a*, left lateral view; *b*, front view, showing the single row of tubercles on the periphery and the asymmetry of the last septal surface, *sl* indicating the siphonal lobe; *c*, peripheral view, showing the single row of tubercles on the periphery and the feeble, imperfectly-defined groove on the right (left in the figure) side at the base of the tubercles. Drawn of the natural size from a specimen in the British Museum collection.

Figs. *b*, *c*) of the whole of the outer whorl is occupied by a single row of rounded and nearly equidistant tubercles. A careful examination of the specimen, however, shows that the whorl is not quite symmetrical; that the row of tubercles is not quite central, but placed a little to the left of the median line; and that on the right[1] at the base of the tubercles (see Figs. *b* and *c*) there is a very feeble, imperfectly-defined groove. As we have already remarked, the anterior end of the specimen is formed by the last septum (see Fig. *b*). This is not quite symmetrical, the siphonal lobe (*sl*) being clearly on the right of the median line, and the lobes and saddles on the right side consequently smaller than those on the left. It is quite clear that the specimen is deformed, and there can be no doubt that it is a deformed example of *Hoplites tuberculatus*. It seems, then, that the tubercles occupying the periphery belong chiefly to the left side, but since the ribs on the right side pass across the very feeble and imperfectly-defined groove, and are also joined to the median row of tubercles, this row may represent also the tubercles belonging to the right side. This opinion is supported by the *shape* of the tubercles, for in the present specimen these are nearly circular and sometimes even transversely elongated in cross-section, whereas in the normal form of the species they are laterally compressed.

[1] The terms 'right' and 'left' are here used in a strictly morphological sense.

IV. — Studies in Edrioasteroidea. I. *Dinocystis Barroisi*, n. g. et sp., Psammites du Condroz.

By F. A. Bather, M.A., F.G.S.

(PLATE XXI.)

Horizon and Locality.

ON April 30th, 1897, the Trustees of the British Museum purchased from Dr. F. Krantz, of Bonn, seven specimens labelled "*Agelacrinus*, n.sp., Unter Devon, Condroz, Frankreich." But the Condroz is a district in Belgium, south of Namur and Liège, between the rivers Meuse and Ourthe; the species do not belong to *Agelacrinus* or any known genus; and the matrix clearly is that of the well-known "Psammites du Condroz," which are Upper, not Lower, Devonian. The species, however, is new, and would have been described by me many months ago had it not been necessary to compare it with other species as rare as they were obscure. The kindness of the authorities at the Imperial University and at the Academy of Sciences in St. Petersburg, the Museum of Practical Geology in London, and, most of all, at the Geological Survey in Ottawa, has enabled me to make a fairly satisfactory study of the forms that elucidate the Condroz species. In addition to them, I have to thank my friend Professor Otto Jaekel, who had at Berlin another specimen of this species, which he purposed introducing to science in his forthcoming Phylogeny of the Pelmatozoa under the name *Dinocystis Barroisi*; on learning that we had more and better specimens for study he generously waived any objections he might have had to my prior publication.

The ascription of these specimens to the "Psammites du Condroz" is confirmed both by the Berlin specimen and by a statement in Dr. Michel Mourlon's "Géologie de la Bélgique" (tome ii, Bruxelles, 1881). A "Liste des fossiles des psammites du Condroz" (p. 23) notes "*Agelacrinus*" as "très-rare" in "Assises de Montfort et d'Évieux," but refers to no published authority for the statement. The "Assises" in question are numbered III and IV by Mourlon, and are the lower two of his divisions of the "psammites" (op. cit., tome i, pp. 92, 93). There is little doubt but that the present species is the *Agelacrinus* of Mourlon.

The "Psammites du Condroz" consist of a micaceous sandstone varying in coarseness, sometimes bluish but, in consequence of weathering, usually brown or even reddish. The calcareous constituents have been leached out, and the fossils occur as either internal casts or external impressions. Unfortunately, the available specimens of *Dinocystis* all belong to the former category. The sandstone may be regarded either as an independent horizon above the Famennian shales and below the Limestone of Etroeungt, or as a littoral equivalent of the typical Famennian shales. The latter view, that adopted by Renevier, is supported by the fact that in the Condroz area the Etroeungt Limestone is replaced by the shales

of Wattignies with *Phacops granulatus*, *Orthotetes crenistria*, and *Clisiophyllum Omaliusi*, while the shales of Colleret and of Cousobre below the "Psammites" have less thickness than the Famennian shales elsewhere. In either case the "Psammites du Condroz" must be taken as the uppermost member of the true Upper Devonian, the succeeding limestones or shales being regarded as beds of passage to the Carboniferous. The known forms most nearly allied to *Dinocystis* have not as yet been found above the Ordovician.

The Material.

The seven specimens preserved in the British Museum are registered E 7,581 to E 7,587, and may here be termed for short **1**, **2**, **3**, etc., respectively. Of these **2** is selected as holotype, while **1** and **3**–**7** constitute the paratypes.

All are internal casts; but **3** and **7** had small portions of matrix adherent to the under side, and these, being broken away, show parts of the impression.

In outline, as seen from above, the fossils are roughly elliptical, but the orientation of the ellipse varies. A line drawn through anus and actinal pole, and called the antero-posterior axis, almost coincides with the long diameter of the ellipse in **1**, **2**, and **6**; in **3** the long diameter is shifted in the direction of the clock-hand about 25°; in **4** about 35°; in **5** about 20°; while in **7** the shift is contrary to the clock-hand about 75°. The measurements of the diameters of the ellipse, in millimetres, are:—

1	**2**	**3**	**4**	**5**	**6**	**7**
43	38·5	35	32·5	30	28·5	24
38·5	31	26·5	27·5	22	23·5	21

Distance of actinal pole from posterior margin, in millimetres:—

1	**2**	**3**	**4**	**5**	**6**	**7**
19·5	16	12·5	12	12	16	14

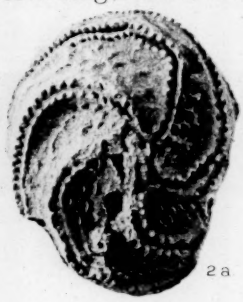
These measurements show that the present shape of the specimens is probably due to contortion after death, whether before or after the consolidation of the matrix. But they further suggest that the tendency was for elongation to take place in an antero-posterior direction, and that in life as in death the actinal centre lay posterior to the geometric centre. To confirm these suggestions there is needed a larger series of specimens, and information concerning their relations to the rock-masses in the field.

Description of the Species on the Evidence of the Seven Specimens.

One may compare the fossil in a rough way to a Tam-o'-Shanter cap or a Breton béret.

The periphery was approximately circular, varying in diameter from 41 mm. (**1**) to 22 mm. (**7**).

From the periphery, the test curved gently over to the upper surface, and rolled gently inwards on the under surface towards


2a.

1a.

3.

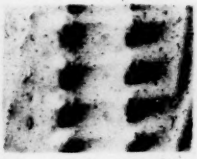
2b.

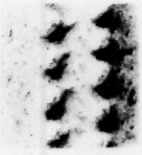
4.

2c.

1b.

5.

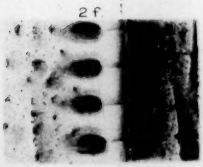

2d.


1c.

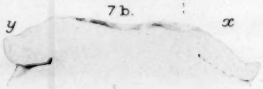
6a.

6b.

2e.


2f.

7a.



7b.

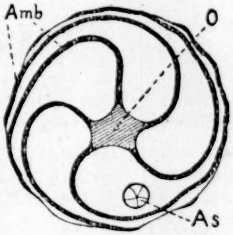
7c.

7d.

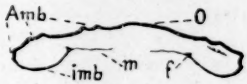
J. Green, Photo., G. C. Chubb, del. Bemrose, Collotype.

DINOCYSTIS BARROISI, 1898.

what would correspond to the opening of the cap. Thus the under surface is hollowed, but since the central region is always filled by matrix one cannot ascertain its structure in full (Pl. XXI, Figs. 1*b*, 2*b*). If the fossil be placed on a flat surface, the actinal pole reaches a height of 14 mm. (**1**), 9 mm. (**2**), 9·5 mm. (**4** and **6**), 6 mm. (**7**). But, owing to the concavity of the under surface, the thickest portion of the actual specimen would be slightly less and would lie about half-way between the actinal pole and the periphery. (Diagram 2.)



1.



2.

Diagrams of Dinocystis.

(1) The upper or actinal surface.
(2) Vertical section across the middle of the test (based chiefly on **3** and **7**).

O, the actinal pole; *Amb*, the five grooves radiating therefrom and passing over the periphery; *As*, anus; *f*, frame of abactinal surface; *imb*, imbricated peripheral area of same; *m*, thin membrane of central area of same.

On the Upper Surface, from the actinal pole, five Radial Grooves pass outwards over the test, each curving as it goes in a sinistral or contra-solar direction (Diagram 1). Each reaches the periphery, and passes along it for fully a fifth of the circumference, or may even pass over to the under surface, so that in nearly all the specimens one or more of the grooves is visible from below.

Apart from the contortion of the specimens, the grooves are not wholly dominated by pentamerous symmetry. They show the primitive division into one anterior, and two pairs of lateral grooves, and are besides not quite regular in their course.

The grooves, as seen on the internal casts, are clearly marked channels, deeper and narrower towards the periphery, where they have undergone more compression. They are bordered on each side by a row of equidistant small knobs, which become smaller distalwards; the knobs are either opposite each other or slightly alternating, and each pair is connected by a faint ridge (Figs. 1*c* and 2*d*). A wax squeeze shows that this appearance is due to the former presence of plates flooring the groove (Figs. 2*e* and *f*). It is probable that these plates originally were in two alternating rows, but that they usually came to lie in pairs without alternation. They may even have fused (as was perhaps also the case in *Haplocystis* Roemer); at any rate there is no sign of a median suture. Between successive plates, on each side, was a pore, represented in the

internal cast by a knob. Of these pores from three to six may be counted in 5 mm., according to the distance from the ambulacral centre (**2**). (Figs. 2*e*, *f*.)

A flattened, elevated, roughly pentagonal area over the actinal pole in **1**, **3**, and **5**, may indicate that this was roofed in by covering-plates. Such a structure may also be inferred from the evidence of allied genera. The covering-plates that doubtless once roofed in the rest of the grooves, were probably removed before fossilization.

The Interradial Areas of the upper surface form slightly concave depressions between the radial grooves. They were covered with polygonal plates (about 2·5 × 2 mm., or less), having their longer diameters parallel to the grooves; there is no evidence that these plates overlapped each other.

In the interradius which (for that reason) has been here termed 'posterior,' lay the anal opening, surrounded apparently by minute plates, the number of which cannot be ascertained. The representation in Diagram 1 is purely diagrammatic. The rounded anal eminence can be recognized on all the casts, at a varying distance from the actinal centre and from the periphery. This interradius is wider than the others near the actinal pole, and in that region probably lay the hydropore. The interradial areas are really continuous with the test of the under surface; but practically they are separated, partly by the almost complete encircling of the periphery by the radial grooves, partly by a rather sudden change in the structure of the test.

The Under, or Abactinal Surface, was divided into two areas, an inner or central, and an outer or peripheral, by a circular Frame, corresponding in position to the rim of a Tam-o'-Shanter, but turned inwards and slightly upwards, not downwards (Diagram 2). Evidence for this frame is presented by specimens **2**, **4**, **3**, and **7**, especially the two latter, which had this region protected by matrix. Removal of the matrix, or cutting across it (Fig. 7*b*), shows a distinct space, triangular in section, encircling the central area. This can only be accounted for by supposing that thicker calcareous plates existed here, and have been dissolved away (cf. Figs. 7*c*, 7*d*).

Peripheral Area.—The frame was depressed to about half the total thickness of the animal, and between it and the periphery there rolled convexly a somewhat flexible integument in which were set minute narrow plates, with their long axes at right angles to the radii of the circle. The edges of these plates appear to have projected outward, towards the periphery of the test, so as to produce an imbrication (**1**, **2**, **3**, **4**, **7**). Flexibility is ascribed to this area chiefly on the evidence of **2**, which shows a radial folding in places.

Central Area.—What was inside the frame cannot be determined satisfactorily. There are in **2**, **3**, and possibly in others, suggestions of a fine and flexible membrane stretched loosely across the opening of the frame. Traces of this are only seen near the edge, and there is no proof that it was continuous. In **2**, however, the visible traces show a fine radial pleating, such as might have been produced, had the membrane been continuous, by some pressure in the central region. (Fig. 2*b*.)

Systematic Position.

Discussion of the meaning of the above-mentioned structures, and of the affinities of the genus, must be postponed until *Edrioaster* has been decently described and figured. I may, however, anticipate by saying that the Condroz form is clearly a close ally of *Edrioaster*, but that it may be distinguished from that genus, as now known, by the tenuity and flexibility of the peripheral area of the abactinal surface, which area in *Edrioaster* is formed of plates no less solid than those in the interradial areas of the actinal surface.

Edrioaster and *Dinocystis* may be separated from the Agelacrinidæ and Cyathocystidæ, as a family Edrioasteridæ, by the absence of a definite border defining the actinal surface, and by the passage of the radial grooves on to the abactinal surface. We may therefore give the following diagnosis of

Dinocystis,[1] gen. nov.

An Edrioasterid with the peripheral region of the abactinal surface composed of a thin flexible integument containing narrow imbricating ossicles.

Genotype : *D. Barroisi*,[2] sp. nov. (= *Agelacrinus*, sp., Mourlon), Upper Devonian, Psammites du Condroz, Belgium.

The characters of the species are of course those of the above description, but one may allude specially to the relatively narrow radial grooves, and to their consistent sinistral curvature. The holotype is in the British Museum, registered E 7,582.

EXPLANATION OF PLATE XXI.

Dinocystis Barroisi.

[All the drawings are from specimens in the British Museum. Figures 1*a*, 1*b*, 2*a*, 2*c*, 3, 4, 5, 6*a*, 6*b* are based on photographs by Mr. J. Green ; the other figures are by Mr. G. C. Chubb. All figures are natural size, except 1*c*, 2*d*, 2*e*, 2*f*, which are × 4 diam., 7*b*, which is × $\frac{3}{2}$, and 7*c* and 7*d*, which are × 2 diam. In all the complete views the right and left of the specimen correspond with the right and left of the observer.]

Fig. 1 (E 7,581). *a*. Actinal surface ; anus distinct in lower interradius.
b. Abactinal surface ; radial grooves are seen at top and on left ; imbricating plates of peripheral area well shown.
c. Distal portion of a radial groove drawn from the specimen.

Fig. 2 (E 7,582). *a*. Actinal surface ; impressions of interradial plates are clear.
b. Seen from anterior end ; the groove in the middle is anterior.
c. Abactinal surface ; the trace of the frame is seen between east and south of the drawing ; the coarse radial folding of the peripheral area and the fine folding of the central area are seen between S. and S.S.W. ; portions of radial grooves are visible at both top and bottom.
d. Portion of anterior radial groove, drawn from specimen just where the groove first curves sharply to the left in Fig. 2*a* ; shows knobs and transverse ridges.

[1] Δεινός, *terrible, wondrous*. It might astonish anyone not acquainted with the true structure of *Edrioaster*.

[2] In honour of Dr. Charles Barrois, whose valuable work on Devonian rocks and fossils, of other districts, must be held to excuse this dedication to him of a fossil with which he has had no obvious connection. The undesirability of applying the names of persons to species, without cogent reason, has been maintained by me so consistently that it will be understood that these names, suggested by Dr. Jaekel, are here adopted merely so as to avoid any possible confusion.

e. Wax squeeze of the same; showing pores and flooring-plates of the groove as they would appear on the inside of the test.

f. Similar squeeze from a part of the groove nearer the periphery, showing the twisting over of the flooring-plates.

Fig. 3 (E 7,583). Actinal surface; the crack running from N.E. to S.W. shows the fracture that enabled the transverse section, Diagram 2, to be reconstructed.

Fig. 4 (E 7,584). Abactinal surface; shows imbrication of peripheral area, and traces of the frame.

Fig. 5 (E 7,585). Actinal surface; the pentagonal area at the actinal pole is well marked, owing to the breaking away of the portion of the cast that represented the covering-plates.

Fig. 6 (E 7,586). *a.* Actinal surface.

b. Abactinal surface; shows large central hollow and traces of frame.

Fig. 7 (E 7,587). *a.* Actinal surface; the line $x—y$ is that of the section *b*; this latter shows the trace of the frame in the left half.

c. Portion of abactinal surface of specimen, showing marked trace of the frame.

d. Wax squeeze from impression of same in matrix, therefore representing outside of test; shows imbricating plates more distinctly, but trace of frame far less distinctly.

V.—The Value of Type-Specimens and Importance of their Preservation.[1]

By Professor O. C. Marsh, M.A., Ph.D., LL.D., F.G.S.;
of Yale College, New Haven, U.S.A.

In the present state of Natural Science, there are too many obstacles in the path of the original investigator. That this is the case in the study of Botany, we may well believe, as authorities of that science have frequently placed the fact on record. It is certainly true that everyone who does original work in systematic Zoology, either among the living or extinct forms, meets many difficulties at the start in endeavouring to ascertain what others have done before him. The literature of the subject is often discouraging from its extent, and especially from its uncertainty. If the work in hand requires the comparison of type-specimens, the difficulties greatly increase, and often prevent definite conclusions. The type will frequently be found the most important element in the problem, far more so than the literature, however extensive. This is more especially true among the extinct vertebrates, with which the present communication mainly deals.

1. *The Value of Type-Specimens.*

The value of a type depends first of all upon whether it is a characteristic specimen, worthy of being the representative of a new group of individuals. Without this distinctive quality, its importance is greatly diminished. If, for example, the specimen first described is immature, its essential features may thus be obscured, and its value as a type much diminished. On the other hand, a very old animal may be uncharacteristic. The teeth of a mammal, for instance, may be worn down or even lost, so as to make the normal dentition uncertain. This is true of recent forms, but is more important if the type belongs to an extinct fauna, as then the chance of duplicating it is much less.

[1] Read before Section B, International Congress of Zoology, Cambridge, England, August 23, 1898.

The value of a type-specimen, again, may depend largely upon its completeness. Among the invertebrates, especially those now living, types are usually complete enough to show the more important features. This, however, is far from being the case among extinct forms, particularly from the older formations, and the records of Palæontology are burdened with the names of many fragmentary fossils, types of species practically unknown.

Among the vertebrates of the past, the case is much more serious, and here especially reform in methods is a pressing necessity. From the nature of the case, the older extinct forms are usually represented by fragmentary remains, the investigation of which is one of the most difficult problems offered to natural science. A single tooth or a vertebra may be the first specimen brought to light in a new region, and thus become the sole representative of a supposed new form. The next explorer may find more perfect fragments of the same or similar forms, and add new names to the category. A third investigator, with better opportunities and more knowledge, may perhaps secure entire skulls or even skeletons from the same horizon, and thus lay a sure foundation for a knowledge of the fauna.

As the number of described forms increases, the necessity of a direct comparison of types becomes imperative, and the comparative value of each type-specimen is thus brought into notice. It will then frequently be found that not a few are uncharacteristic, while others are too incomplete to disclose their own essential features, and hence of little aid in indicating the affinities of forms found with them.

Type-specimens that do not show characteristic features are, of course, of little value to science, and many such prove a delusion and a snare to the investigator, however faithfully he may endeavour to study them. The imperfect types require still more labour to decipher them. Not a few specimens to-day are types, for the simple reason that they are imperfect. If they had been entire when described, their true nature would have been recognized, and much confusion in nomenclature have been avoided. The chance preservation of some marked features may, indeed, give a hint as to what the whole specimen once was, but too often a suggestion only is thus offered, while the real nature of such types must always remain in doubt.

A type in Palæontology should consist of the remains of a single individual, and this should stand as the original representative of the name given. A second specimen, or even more, may be used later to supplement the first, but not to supplant it. This, however, has been done by some authors, with the natural result of causing endless confusion in the nomenclature.

2. *The Selection of Type-Specimens.*

The descriptions in Palæontology are too often descriptive only, and not comparative. This, if well done, is preferable to long academic discussions in regard to the affinities of a specimen of

which the main characters are not known, or not placed on record. A vertebra of a reptile or the tooth of a mammal, if perfect and characteristic, may form a type that will be distinctive enough for the present requirements of the investigator. What the future may demand, will depend upon the advance of knowledge in that branch of science.

In the choice of specimens worthy of being types, I can only suggest a course that seems to me the proper one. I believe experience has already shown that to make types of incomplete or uncharacteristic specimens is seldom of permanent advantage to an author, and almost always a lasting injury to the branch of science he represents. There are more good specimens waiting to be found than any naturalist can possibly describe, and one such specimen is worth many of inferior grade.

I may perhaps be permitted to mention in this connection my own experience in the matter of type-specimens. As a student in Germany, years ago, I had my attention called particularly to this subject, and was then strongly impressed with the importance of using only good specimens for first descriptions. This rule I have endeavoured to follow. My researches, especially in western North America, have resulted in the discovery of more than one thousand new species of extinct vertebrates, and of these I have described about five hundred. Had I been satisfied to use inferior specimens as types, I might have increased the number by one-half at least.

No small part of the present literature of the palæontology of vertebrates is based on names applied to fragments, and a long period of more accurate work will be required before these can be rejected or incorporated into the digested knowledge of the subject. I recall one collection of types of extinct vertebrates, published in a single volume, and near a hundred in number, the greater part of which are uncharacteristic fragments, well fitted to burden science for all time with a legacy of uncertainty and doubt. Such work is a positive discouragement to all future investigators in the same field, and its value to science may well be questioned.

The necessity of greater care in selecting type-specimens, in Palæontology at least, needs no argument to any student of the science who has done sufficient original work to appreciate the increasing difficulties of accurate investigation. To those who have had less experience, a word of warning, I trust, will not be in vain.

3. *The Preservation of Type-Specimens.*

The careful preservation of their own type-specimens is a sacred duty on the part of all original investigators, and hardly less so of those who are the custodians of such invaluable evidence of the progress of natural science.

Local museums, as a rule, are less desirable repositories of type-specimens than private collections, since the former usually can have little hope of permanent care, while the latter, if important, have a fair chance, by gift or purchase, of becoming part of a large endowed museum, where those in control are more likely to appreciate the importance of types, and carefully preserve them.

For the preservation of type-specimens, fire-proof buildings are indispensable. I recall no less than five Museums of Natural History, in America, that have either been destroyed, or their contents consumed, or seriously damaged by fire, since I became actively interested in natural science. Several others, in the meantime, have had narrow escapes from the same danger, so that I regard all type-specimens as insecure that are not preserved in buildings practically safe from fire.

Another danger to which type-specimens are subject, is loss or injury during transit, when loaned or otherwise sent away from their regular place of deposit. This evil has become so serious, that some museum authorities do not permit type-specimens to leave the building. This I regard as a wise regulation, and it is now in force at New Haven and various other scientific centres.

If a type-specimen be important, the investigator will come to the type. I once made a long pilgrimage to a famous university town, mainly to see a single bone, the 'tibia' of an extinct reptile, according to the description, and the type of a new genus. I found the bone in good custody, and well preserved. It was not a tibia, however, but a radius, and this fact changed the classification based upon it. Had that bone been lost or destroyed, a new animal of strange proportions might have existed on the records of Palæontology, if not in Nature. That bone fortunately is still preserved, a witness whose testimony is conclusive.

When fossil skeletons are discovered in position, the best methods of preservation, especially of types, requires the retention as nearly as possible of the bones as found. One fore and one hind foot, at least, should always be kept in the rock, and all impressions in the matrix carefully preserved.

The importance of indelibly marking type-specimens, and the separate parts of each, so that they may be studied essentially as found, is also evident. If a type is restored with plaster or other substance, the limits of each should not be so obscured that investigators cannot distinguish them. These are not imaginary precautions. Cases of the kind mentioned are not uncommon in vertebrate palæontology, as every worker knows. One well-known skull, with portions now preserved in two museums, is restored in one of them, as an original, and is thus misleading.

Type-specimens preserved from other dangers may be injured unintentionally. Among the rare specimens damaged by zealous but unskilful hands in the house of their friends, three of the most important to palæontology, a reptile, a bird, and a mammal, are well-known examples, and not a few others both in this country and America might be mentioned if it were proper to do so on this occasion. Such lack of intelligent custody of types will make the work of future investigators much more difficult.

An indirect way of preserving type-specimens is by means of casts. These, if accurately made, may be of much service, and, in fact, an insurance on the original specimen. They may often save an investigator a long journey, and in case the type itself is

lost or destroyed, the copy may prove of great value in indicating what the name was intended to cover.

Another indirect means of protecting type-specimens would be to publish catalogues of them, giving the places where they are preserved. Such a list of a single group would be of great service to anyone investigating it, and could be renewed from time to time whenever necessary. It would be well if everyone who described a species also stated where the type was deposited. In time this would become the established usage, and thus greatly facilitate the preparation of catalogues of types and their places of preservation.

Palæontology has been called an exact science, but its records up to the present time do not bear out this statement. If, as I believe, it will yet be worthy of such a distinction, one means of its advancement will be for those who represent it to select better type-specimens, and preserve them more carefully.

In all branches of Natural Science, type-specimens are the lights that mark the present boundaries of knowledge. They should be, therefore, not will-o'-the-wisps, leading unwary votaries of science astray, but fixed beacon lights to guide and encourage investigators in their search for new truth.

VI.—Blind Trilobites.

By F. R. Cowper Reed, M.A., F.G.S.

(*Concluded from the November Number*, p. 506.)

THE majority of fossiliferous beds in the Cambrian are of an argillaceous nature, and limestones are comparatively rare, but we need not here enter into a discussion as to the causes of their rarity. When, however, we come to the Ordovician, we find calcareous beds much developed, and since we find in them, as well as in the slates and shales, these blind genera, and as far as we know not less abundantly, it appears as if the physical conditions of sedimentation had but little to do with the existence and perpetuation of these forms. We cannot, therefore, argue that their survival was a direct result of a similar physical environment; but probably biological influences which we cannot now gauge played an important part, and to some extent determined their survival. Barrande, on the other hand, held strongly to the opinion that the pellucidity of the water in which limestones were formed led to or was associated with the absence of blind trilobites, and believed that it was owing to the muddy waters in which argillaceous sediment was deposited that the eyeless and large-eyed trilobites were especially abundant. The evidence which induced him to hold this view was obtained in Bohemia, where he noticed that in the Second Fauna (which corresponds in a general way to our Ordovician) the majority of the blind trilobites were found in the fine argillaceous slates of D*d* 1 and D*d* 5, while the fewest occurred in those rocks (quartzites and

limestones) which accumulated in comparatively clear and pure water. On the other hand, in the British Isles, Sweden, and Russia, when once we get above the Cambrian, there are just as many blind genera in our Group 1 occurring in calcareous beds (e.g. the Keisley and Kildare Limestones, the *Leptæna* Limestone, and the Russian homotaxial limestones) as in shales and slates; and, in fact, some of the blind genera seem restricted to these limestones (*Tiresias*, *Isocolus*). The character of the sediment seems also to have but little to do with the presence or absence of the 'adaptive' species in our Group 2, for while in Bohemia Barrande notices that the blind species of *Illænus* occur in the fine argillaceous slates, the northern species of the same genus occur principally in the above-mentioned limestones.

Barrande (loc. cit.) also lays stress on the fact that the large-eyed genera *Æglina* and *Remopleurides* only are found in the two bands of fine argillaceous shale, D*d* 1, D*d* 5, in which occur the majority of the blind forms of the Second Fauna; and that in the Primordial fauna of Étage C an analogous state of things exists in the association of the large-eyed *Paradoxides* and *Hydrocephalus* with the eyeless forms. In both cases he imagines the same cause to have been operative, i.e. the turbid muddy state of the water, which made eyes of a normal size useless and led either to the development of enormous visual organs or to the degeneration and loss of those of an ordinary character. Whatever connection, however, these cases may indicate between the association of blind with large-eyed forms, it cannot apparently have been one universally induced by such a cause as Barrande supposes, for we find the large-eyed and blind forms of our Group 1 occurring together in calcareous beds, such as the Keisley and homotaxial Limestones, in which the conditions of deposition must have been of an utterly opposite character. The difference in the facies of the faunas associated shows that the bionomic conditions must also have been dissimilar.

In connection with the question of the action of the environment on the structure or sense-organs of animals, we may refer to Neumayr's[1] arguments in favour of regarding the Cambrian fauna as indicating conditions analogous to those now existing in the deep sea, especially as he makes so strong a point of the occurrence of blind trilobites. After the foregoing careful consideration of the subject, it will only be necessary to sketch briefly the kind of answers which may be made to his arguments, and the different explanations possible of the phenomena which he adduces. He mentions four peculiarities of the Cambrian fauna which make him believe that it represents deep-sea conditions:—

(1) Its wide distribution; but we have remarked above that this merely indicates uniform conditions of life, and that such most probably existed in early geological times.

(2) Its impoverished character as a fauna, shown by its poverty in variety of types, since it consists chiefly of trilobites and

[1] Erdgeschichte, vol. ii, p. 51.

brachiopods with only rare representatives of other groups. In so far as this argument affects our subject of consideration we may remark that (*a*) a variety of types is not necessarily demanded in such an early geological period; (*b*) an impoverished fauna is capable of several other explanations than deep-sea conditions, as for instance the Permian. The superabundance of two such groups of organisms as trilobites and brachiopods is not of much value as evidence, since one group is extinct and the other is by no means characteristic of the deep sea (*Lingula*, the oldest surviving type, being in fact an inhabitant of shallow water).

(3) The almost complete want of organisms with skeletons of carbonate of lime. To this the reply may be made that modern deep-sea deposits consist largely of carbonate of lime, and are mostly composed of the remains of animals that secreted carbonate of lime, with the exception of the Radiolarian Ooze and Red Clay, to which few, if any, Cambrian trilobite-bearing deposits can be compared except by neglecting many characteristic features or making unwarrantable assumptions.

(4) The occurrence of blind and large-eyed animals. If we leave out of the question the disputed *Paradoxides* and allies, all the blind genera which Neumayr here refers to are devoid of eyes because of their phylogenetic position, as we have shown. Neumayr regards all these forms as having lost their eyes by a secondary modification, and quotes *Trinucleus Bucklandi*, which as we have remarked possesses visual organs when in a larval stage, but loses them at maturity. But these are eye-spots and not compound eyes, and are not characteristic of any phylogenetic stage. Their significance has been discussed above. An example which has been supposed[1] to be similar (but is probably not so, as the eyes are of the normal crustacean type) is that of the deep-sea decapod *Willemœsia*, the embryo of which is said to possess well-developed eyes. The eyes of the larval *Trinucleus*, on the other hand, are not normal trilobite eyes. Neumayr also lays stress on the association of blind and large-eyed forms. But we have just dismissed the majority of blind ones from the question, and have seen that they are to be explained in a totally different manner, resting on the ascertained facts of phylogeny and ontogeny, and not on theoretical considerations. So the occurrence of the large-eyed forms such as *Æglina* and *Remopleurides* must be dealt with alone. The great development of visual organs, though a striking character in many deep-sea Crustacea (e.g. *Cystisoma neptunus*) and other deep-sea organisms, is not confined to them; nocturnal and cave-frequenting animals have extraordinarily developed powers of sight, and, as we have mentioned, Barrande indeed suggested the muddiness and therefore comparative shallowness of the water in which these trilobites lived as a sufficient cause. But the large-eyed *Remopleurides* frequently occur in limestones which accumulated in clear water. Perhaps the large eyes served simply for the better

[1] W. Marshall, "Die Tiefsee und ihr Tierleben" (Leipzig, 1888), p. 265.

detection of enemies, or the capture of prey, and were correlated with a lack of agility; at any rate the evidence is antagonistic to supposing that they signify deep-water conditions. It should be observed also that the character of the fauna associated with these large-eyed genera varies much, as we may at once see in examining the lists of organisms from the beds in which they occur.

It is a remarkable fact that in the case of such deep-sea deposits as the Culm beds which are associated with the Radiolarian cherts of Devonshire,[1] none of the trilobites show degeneration or abnormal development of their eyes.

The highly-developed trilobites such as *Encrinurus*, *Cybele*, *Acidaspis*, many species of *Phacops*, etc., which possess eyes smaller than the average, are not found in deposits or with associated faunas suggestive of deep-sea conditions. We have also no reason to suppose that those species of *Phacops* and *Proetus* with unusually large eyes lived in the abysses of the ocean, for the lithological character of the deposits and the features of their contemporaneous faunas point usually to the existence of shallow water.

Conditions of Life of Blind Trilobites and Comparison with Modern Blind Crustacea.

The most popular and widely accepted view of the conditions under which the blind forms lived is that put forward prominently by Suess, Neumayr, and others. They suppose that these forms existed under deep-sea conditions, and that the partial or complete absence of light in the abysses of the ocean led either to the reduction or loss of the visual organs or to their enlargement to an extraordinary degree. In the first place, before we test this theory and see how far it satisfies the facts of the case, we must remember that it is a theory of adaptation and therefore cannot be applied to those genera which, as we have seen, could never have possessed compound eyes because of their low phylogenetic rank. Accordingly we have to exclude all the genera of our Group 1, for we have shown that we cannot even consider the post-Cambrian primitive blind forms as surviving on account of a maintenance or repetition of an identical biological or physical environment, but rather because they occupied a place in the economy of nature which higher forms could not fill. The survival of all primitive and lowly forms of life at the present day appears to be due to this cause.[2]

We must therefore consider that all theories of adaptation are only applicable to our Group 2, which consists of what we have called, *a priori*, the adaptive blind forms, because their blindness is an

[1] G. J. Hinde: Q.J.G.S., vol. li (1895), p. 609; Trans Dev. Assoc., vol. xxviii (1896), p. 747; ibid., vol. xxix (1897), p. 518.

[2] Suess ("Antlitz der Erde," vol. ii, p. 274), however, regards the oldest known fauna of the Bohemian Silurian beds (i.e. E'tage C) to be an 'adapted' fauna, and therefore the successor of a still older and unknown fauna. But he seems to arrive at this opinion by neglecting the testimony of phylogeny and ontogeny, and by regarding the absence of eyes in every case necessarily as an adaptive feature.

exception in the genus to which they belong, and their phylogenetic rank (with the exception of *Harpes*) demands that compound eyes should be present. We must seek therefore for the special conditions which lead to the loss of eyesight.

In the case of modern marine animals it is found that a large number of those inhabiting the abysses of the ocean, to which few or no rays of sunlight can penetrate, are either devoid of eyes or have these organs enormously developed, while closely allied species or genera living in well-illuminated zones of the sea have normal eyes. From the analogy of blind cave-animals it is generally believed that this state of things is due directly to the absence or feebleness of the light at the bottom of the deep sea. Packard[1] discusses the question and says that "it is most probable that the causes of atrophy or blindness under one set of conditions [i.e. in caves] are the same or nearly the same as in the other." But this is questionable, and, apart from the action of other factors, such as pressure and equable temperature, which operate in the deep sea, the facts gathered by Professor S. J. Smith[2] from the dredgings of the "Albatross" indicate "some difference in the conditions as to light in caverns and in the abysses of the ocean, and make it appear probable that in spite of the objections of the physicists some kind of luminous vibrations do penetrate to depths exceeding even 2,000 fathoms." If we exclude shallow-water species, no definite relation has been traced between the amount of modification of the eyes and the depth which the species inhabit. The experiments of Forel, Asper, Fol, and Sarasin, on the depth to which the rays of sunlight penetrate which affect photographic plates, were not made in mid-ocean, where the purity and transparency of the water is said to be much greater than near shore or in lakes; and, moreover, we are not bound to assume that the limits of luminous perception are the same for the retina and visual nerves of all the lower animals. It is, however, proved that "although some abyssal species do have well-developed eyes, there can be no question that there is a tendency towards very radical modification or obliteration of the normal visual organs in species inhabiting deep water" (Packard). The amount of modification appears to depend to some extent on the length of the period during which the organism has inhabited the deep water. Thus *Pentacheles*, which belongs to a group believed to have frequented deep water for considerable geological periods, has highly modified eyes, while the species more closely allied to shallow-water forms have less modified or only partially reduced eyes, suggesting a more recent immigration into the abyssal regions. In the case of those deep-sea fishes, as Lendenfeld has said, in which the eye was originally strong and well constructed, and the migration into deep water gradual and spread over many generations, the eye became gradually enlarged; but in those forms in which the eye was originally weak

[1] "Cave Fauna of North America": Nat. Acad. Sci., vol. iv (1886), Mem. 1, pp. 116–137.

[2] Ann. Mag. Nat. Hist., 1886, pp. 194–7.

and the change of habitat too rapid for adaptation of the organ to the new conditions, it degenerated and atrophied. There may be little truth in Verrill's view that more or less sunlight penetrates to the greatest depths, giving an illumination at 2,000 to 3,000 fathoms perhaps equal to our partially moonlight nights, and possibly at greater depths equal to starlight; but McCulloch and Coldstream's clever suggestion that the light of phosphorescent organisms supplies the place of sunlight in the deep sea has much probability in it when we consider the great development of phosphorescent organs in animals at abyssal depths. Hickson[1] remarks that phosphorescence is only locally distributed, and that in some regions the darkness is so absolute that it can only be compared with the darkness of the great caves. The fact that the fauna of the deep sea does not entirely consist of blind or large-eyed forms is partly explicable on this view, but is probably to a larger extent due to the immigration of species with normally developed eyes which has always been taking place from the shallow-water regions. It is to be remembered that the majority of modern deep-sea animals are merely modified types of shallow-water forms, and that there are few which can be considered ancestral in character. Thus, even if other considerations already discussed allowed us to consider the blind trilobites belonging to our 'Primitive' group as members of a deep-sea adapted fauna, the abundance and large proportion of such ancestral types would be contrary to modern analogy. Many characteristic modern deep-sea forms also may occasionally wander into shallower regions where faint rays of sunlight penetrate, and the young stages of others may be passed at or near the surface of the sea.[2]

It is not, therefore, very surprising that very few animals belonging to families usually provided with eyes are completely blind. Hickson remarks that the large-eyed forms preponderate from 300–600 fathoms, which includes the region which rays of sunlight faintly penetrate. But in water of over 1,000 fathoms small-eyed and blind forms are in a majority, for it is below the sunlight limit, and eyes are therefore for the most part useless.

Agassiz[3] has said that it is difficult to draw any conclusions from the great diversity presented by the organs of sight in the Crustacea, and that one cannot help being struck by the small number of deep-sea Crustacea which have lost their eyes. It is well to bear in mind his caution[4] as to "drawing conclusions with reference to physical conditions derived from organs of sense which may serve other purposes than that of vision alone."

It must also be remembered that there are many blind Crustacea and other marine invertebrates either without eyes or with only rudimentary organs of sight which have been dredged from comparatively shallow water. From the habits of these forms it

[1] "Fauna of the Deep Sea" (Mod. Sci. Series), pp. 22-28.

[2] Hickson, loc. cit.

[3] Three Cruises of the "Blake," vol. ii, p. 44. See also W. Marshall, "Die Tiefsee und ihr Tierleben" (Leipzig, 1888), p. 260, etc.

[4] Ibid., vol. i, p. 308.

seems that their mode of life here leads to just the same modifications as the deep-water conditions. It is not, indeed, improbable that the similar mode of life in many deep-sea forms has more to do directly with their blindness than the fact that light is practically or nearly absent in the abysses of the ocean. Thus Agassiz (loc. cit.) says that the deep-sea blind fishes belong to families with burrowing habits, and the same may be said of the blind Crustacea and Gastropoda. Semper[1] has pointed out that many blind animals live in well-illuminated situations.

Many Isopods are blind in shallow water as well as in the deep sea (e.g. *Munnopsis* and *Eurycope*). *Pleurogonium* is quite blind in 20 fathoms of water, and the much quoted blind species *Petalophthalmus armiger* ranges from 140 to 2,285 fathoms, and *Pseudomma Sarsi* from 110 to 1,500 fathoms.[2] The forms which grub in the mud have frequently no eyes,[3] while free-swimming allied species have well-developed eyes. Marshall[4] remarks that it is very strange that the blind Schizopod *Pseudomma australe* lives in only 33 fathoms of water, but he does not give any account of its habits.

Indeed, benthonic conditions of life seem to lead to reduction or loss of eyes, whether the organisms live in deep water or shallow. Packard (loc. cit.) suggests that it may be found that the deep-sea forms without eyes burrow in the ooze or live under loose objects at the bottom, thus being subjected to conditions which may be completely paralleled in shallow water, and which the above examples seem to show produce the same results.

Semper (loc. cit.) also mentions a fact showing that other causes as well as the absence of light lead to the loss of the eyes. Thus, in the cave-beetle *Machærites* the females are blind, but the males have well-developed eyes. It is also a well-known fact that the free-swimming larvæ of parasitic Crustacea and the Holothurians possess organs of vision, whereas the adults have no eyes, though frequently living in well-illuminated portions of the sea. The mode of life has made eyes superfluous, and therefore they have been lost.

Turning now to the blind trilobites to see how the above facts derived from living Crustacea apply to them, we notice that the members of our Group 2—i.e. the 'adaptive forms'—have not a wide distribution; they are mostly local forms found only in a small and restricted area. The wide distribution of modern deep-sea species finds therefore no analogy in them; and the statement that it does is due to the inclusion of those phylogenetically blind forms which belong to our Group 1. Incidentally it may be remarked that the wide distribution of these phylogenetically blind genera may be due to the same cause as that which causes the wide distribution of modern deep-sea organisms, and this cause is the uniformity of physical conditions, particularly of temperature, which

[1] "Animal Life" (Internat. Sci. Ser.), pp. 76–87 and 419–421.
[2] Walther, Einleitung in die Geol., etc. (Jena, 1893–4), pp. 43, 44.
[3] Sars, Chall. Rep., vol. xxxvii.
[4] Die Tiefsee und ihr Tierleben, 1888, p. 265.

we know prevails at great depths, and which with considerable probability is held to have existed in early geological times over wide areas owing to the non-differentiation of climatic zones.

It is also deserving of mention that the very character of the beds which accumulated in the Lower Cambrian Period in Wales, where so many of the blind genera of our Group 1 are found, points to rapidity of deposition and fairly shallow water.[1]

Some members of our 'adaptive' group of blind trilobites probably lost their eyes as a result of their burrowing habits in the soft ooze on the sea-floor, or from frequenting muddy turbid waters in which organs of vision would be of little or no service, as Barrande suggested for the Bohemian forms in the Ordovician shales. Others may have inhabited submarine caves into which few rays of light could penetrate, and natural selection may have developed other organs of sense of greater use to them than eyes. A few may have generally lived in the deep-sea abysses, and occasionally have visited the shallower regions, in which their remains were entombed in the deposits there accumulating. Others may have lived in shallow water, but possessed delicate tactile organs and more highly-developed other sensory powers as a compensation for the absence of eyes. Others may have possessed nocturnal habits. If it be difficult to account for the blindness of many living shallow-water Crustacea we ought not to be surprised if we find greater difficulty in discovering any satisfactory explanation of some fossil forms. But, as above suggested, there are several ways of reasonably accounting for the absence of eyes, and we need not despair of ultimately solving each difficult case.

Conclusion.

From the above examination into the nature and distribution of blind trilobites we have seen that the great majority of them are primitive forms, possessing no compound eyes because of their low phylogenetic rank and great geological age. No question of adaptation to environment therefore concerns these blind forms. But there is a small number of blind trilobites which we are led to believe owe their blindness to degeneration of the visual organs as a result of certain conditions of life. From the physical and biological evidence of their occurrence we must suppose that different factors have produced the same result. We have seen that amongst modern Crustacea blindness is a condition brought about by a variety of causes, and is by no means always dependent on their bathymetrical distribution or aphotic habitat. Such appears also to have been the case in the geological past, and each instance must be considered on its own merits and with due attention to circumstantial evidence.

[1] Hicks, Pres. Add., Proc. Geol. Soc., 1897, vol. liii, p. 68.

VII.—On the Occurrence of Arenig Shales beneath the Carboniferous Rocks at the Menai Bridge.[1]

By Edward Greenly, F.G.S.

THE shore of the Menai Straits on the Carnarvonshire side, near the Suspension Bridge, is composed, as is well known, of sandstones and shales belonging to the Carboniferous Series. About a quarter of a mile west of the bridge, however, some fissile, reddish and greenish shales appear on the foreshore, dipping at higher angles than usual. This might easily be ascribed to local disturbance, as a large fault is not far off, though the shale differs somewhat from that which is common in the Carboniferous rocks of the district, a fact which was noticed by Mr. G. H. Morton,[2] who went with me along this part of the section. The difference, however, might easily escape the eye, especially as the exposures are small. The dip is about 25°–30° S.E. or S.S.E., but sometimes as high as 50°. The shales soon rise into a low cliff, overhung by woods which mask their relation to the Carboniferous rocks to the east, and extend along the shore for about 80 yards as far as a little glade in the woods, beyond which drift comes down to high-water mark for about another 80 yards. The shales here rise again, and form a little rocky point some 20 to 30 feet high, where the red and green varieties can be seen to be merely the upper and stained portion of a mass of black shales, which form the lower part of the rocky point and the foreshore. These are dark, evenly bedded, platy shales, very fissile, and quite unlike anything in the Carboniferous system in this district, but strongly resembling the usual Ordovician type of S.E. Anglesey and the Straits. They are quite uncleaved, and dip E.S.E. at about 25°. Drift then again conceals the rock for about another 80 yards, beyond which the annexed section is seen.

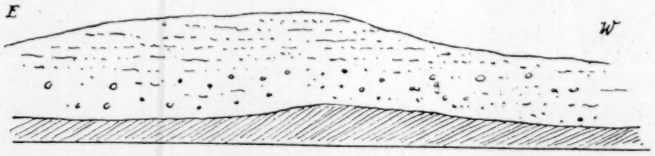


Fig. 1.—Sketch of section on shore below Treborth.

At the top are four or five feet of red and green, soft, flaggy sandstones, very micaceous, and of a type common in the Carboniferous rocks; passing down into about two feet of pebbly sandstone or conglomerate, which rests upon the same reddish fissile shales as those above described. The junction is only a foot or two above high-water mark, to which the sandy beds descend in a few yards, after which they form the whole cliff and foreshore, the shales not reappearing so far as I have been able to see. In this section the sandy beds are practically horizontal, while the shales dip E.S.E. at

[1] Communicated to the British Association, Bristol, 1898.

[2] The Carboniferous rocks here seen will shortly, I hope, be described by him.

about 25° to 30°, and the line of junction is exposed, obscured only in places by a little stalagmite. The base of the pebbly sandstone, which is a little uneven, overhangs in a little shelf, underneath which the upturned edges of the reddened shales upon which it rests can be clearly seen.

Further, the shales, in their black, unstained portions, have yielded the following fossils:[1] *Didymograptus patulus*, Hall; *Did. nitidus*, Hall; *Did. extensus*?, Hall; *Climacograptus*?; and *Caryocaris*—an unmistakable Arenig assemblage. One stipe of *Did. nitidus* measured $1\frac{3}{4}$ inch and is incomplete, and another of probably *Did. extensus* is two inches in length.

It is clear, therefore, that the base of the Carboniferous rocks is exposed in this shore section, and that they rest unconformably upon a series of black shales of Arenig age.

I had for some time hoped to find an exposure of such rocks in the vicinity of the Bridge, for the following reason:—At Tyn y Caeau on the Holyhead Road, about a quarter of a mile west of the Bridge Village, there is a large section in glacial gravels, which are composed chiefly of well-rounded pebbles of a soft black shale. The shale is of Ordovician type, and the pebbles have yielded *Didymograptus Murchisoni*; *Did. bifidus*, Hall; *Did. extensus*?, Hall; *Did. patulus*, Hall; *Caryocaris Wrightii*, Salter; *Caryocaris*; and *Lingula* or *Lingulella*. I know of no such shale in the neighbourhood on the Anglesey side. The gravels appear to rest upon and to be completely surrounded by crystalline schists, and, as the general direction of transport of the blocks in the drift is from the north-east, the beds from which the fossiliferous pebbles have been derived are probably concealed beneath the waters of the Straits a little to the north-east of the Suspension Bridge.

There is some reason to suppose, indeed, that the floor of the Straits east of the Tubular Bridge is in great part composed of these Ordovician shales. For, as the Carboniferous rocks, though lying at low angles, dip on the whole to the south-east, and as we have seen that their base rises above high-water mark for about 250 yards of the shore on the Carnarvonshire side, it is improbable that they cover much of the floor of the Straits, which descends to

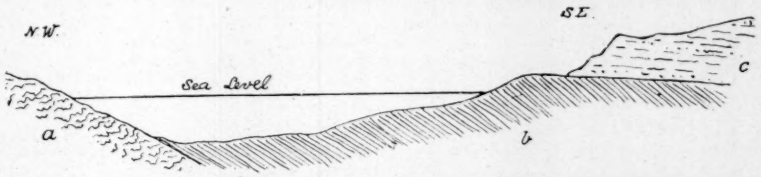


FIG. 2.—Hypothetical section through the Menai Straits between the bridges.
a, Crystalline Schists. *b*, Arenig Shales. *c*, Carboniferous Sandstone.

some 40 feet below that level. The evidence yielded by the gravels above mentioned points to an extension of the Ordovician shales

[1] The graptolites and other fossils mentioned in this paper have been examined, with his usual kindness, by my friend and former colleague, Mr. B. N. Peach, F.R.S.

along the hollow to the N.E. of the exposure described in this paper; and dark shales of the same lithological character are known to occur below high-water mark on the Anglesey shore at Garth Ferry. The existence of such a band of shale must have been an important element in determining the excavation of the Straits, by whatever agency we suppose them to have been eroded. For, as soon as the retreat of the Carboniferous escarpment began to expose the shales, erosion would be facilitated, and their direction of strike would tend to accentuate, if it did not initiate, the N.E.–S.W. trend of the hollow.

VIII.—Note on the Martley Quartzite.

By Theodore Groom, M.A., D.Sc., Professor of Natural History at the Royal Agricultural College, Cirencester.

My attention has been drawn to a recent notice[1] by Mr. Coles of a quartzite at Martley. Since this area is included within the district of the Malvern and Abberley Hills, which I have been engaged in studying for more than two years, a brief description of the relations of the rocks, as determined by myself in January of the present year, may not be out of place. The small patch of interesting rocks here is likely to become covered up as cultivation progresses; indeed, the exposure is evidently much less extensive than it was when Phillips described it in his memoir on the Malvern and Abberley Hills. Mr. Coles has, moreover, I think, hardly done justice to the remarkable section exposed here.

On certain points I am quite in agreement with Mr. Coles. The lowest rock seen is certainly a quartzite of the type found in the Lickey Hills, Wrekin, and, as I hope to show soon, in the Malverns and in Cowleigh Park.

I could detect no traces of fossils in the Martley rock, though the corresponding quartzite of the Malvern Hills is richly fossiliferous in places.

The quartzite, somewhat shattered, is arranged in the form of a plicated anticline, or anticlinal dome, dipping towards the west and east, and showing a tendency to a *quâ-quaversal* arrangement. The visible thickness of the quartzite is about 42 inches, although, the base not being seen, a much greater thickness may be present.

The uppermost rock seen, termed by Mr. Coles a "quartziferous mica-syenite, or possibly a diorite," is indistinguishable from the crushed coarse diorite prevalent in many parts of the Malvern range.

The diorite is separated from the quartzite by two feet or more of greenish schists, the "powdery rotten rock" of Mr. Coles. The foliation of the schists is parallel to the surface of the quartzite, and to what is apparently bedding in the latter. These schists essentially resemble certain of those formed by dynamo-metamorphism in the Malvern Chain, as shown by Dr. Callaway.

The most remarkable feature in the section is the superposition of the diorite and schists on the quartzite; the readiest explanation

[1] "An exposure of Quartzite and Syenitic Rock near Martley, Worcestershire": Geological Magazine, 1898, p. 304.

of this fact would be that we have here a quartzite interstratified with rocks of the Malvernian Series.

Mr. Coles suggests that the apparent relation seen here is "not the real one." If by this be meant not the original one, I am quite in accordance with him. Quartzites certainly occur on a limited scale interfoliated with gneissic and schistose rocks in the Malvern Hills, but they are of quite a different type to that seen at Martley, being, in fact, quartz-schists representing, according to Dr. Callaway, the extreme metamorphism of felsites and gneissoid quartzites produced from diorites.

The Martley quartzite, on the other hand, as Mr. Coles shows, and as my own investigations prove, is a typical sedimentary rock, with a microscopic structure essentially similar to that of the Cambrian quartzite of the Malvern Hills.

I have already maintained[1] that in the Malvern area the Malvernian Series is sometimes thrust on to the Cambrian beds.

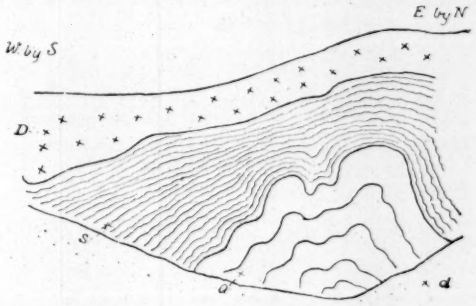


Fig. 1.—Section in the Gravel Pit near Martley.
D. Diorite.
S. Schists.
Q. Quartzite.
d. Detritus.
Length $ab = 9$ ft. 6 in.

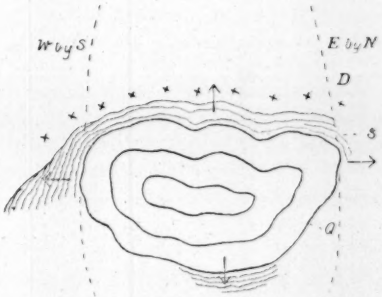


Fig. 2.—Ground-plan of same (diagrammatic). The dotted lines indicate roughly the probable limits of the outcrop of the quartzite on a surface at the level of the floor of the pit.

[1] Ann. Rep. Brit. Assoc., 1898.

This is the explanation I would also apply here. The Archæan mass thrust over the quartzite during a period of intense folding, has been sheared at its base, so as to give rise to the underlying green schists with their foliation parallel to the thrust-plane.

The anticlinal arrangement of the rocks is perhaps due to a subsequent movement, analogous to that which appears to have affected the thrust-plane in Raggedstone Hill, as I hope to show very shortly.

This hypothesis clears the way for the acceptance of the Cambrian age of the Martley quartzite.

IX.—Glacier Motion and Erosion.

By R. M. Deeley, F.G.S.

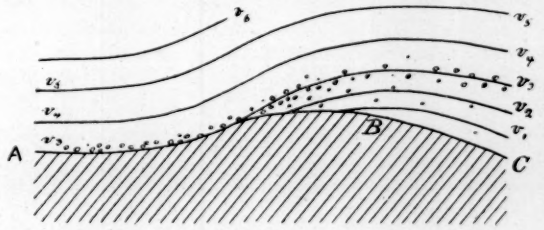
ALTHOUGH the ice of many glaciers, more especially those which move over massive impervious rocks, is clean and almost free from rock fragments, in many cases towards the bottom of the glacier, boulders, pebbles, and even masses of clay, mud, or sand abound. The rock-masses have evidently been derived from the floor over which the glaciers move, for the fragments become more numerous as we descend in the ice, the upper portion of the glacier being often quite free from foreign matter.

The process by which the boulders rise and become imbedded in the glacier would seem to be somewhat in conflict with our notions of viscous flow, for the stream lines in viscous fluids are always regarded as being direct. It has, however, been pointed out that when a glacier encounters an obstacle a portion of it may pass over the top, and flow over the streams of ice working round the sides. In this way boulders from near the summit of the crag may be trailed over the side streams and thus become imbedded in the mass of the glacier. This explanation may account for some of the intrusions met with, but scarcely seems sufficient to explain the presence of the great quantities of material sometimes found in the lower portions of some large glaciers or ice lobes.

I have pointed out in a previous paper[1] that a viscous substance may be either adherent to its bed or slide slowly over it. Pitch, for instance, adheres firmly to the sides of its channel, and the flow results wholly from the shear of layers of pitch over layers of pitch, the molecules actually in contact with the sides being for all practical purposes stationary. The ice of a glacier, on the other hand, is frequently separated from the rock upon which it rests by a film of water, and moves bodily as well as by the differential motion of its particles. But in both cases the flow is direct and could not cause boulders to work their way from the sides or bottom into the mass. Such a result, however, could be produced if the viscous body were *sliding* over its bed in some places and *adhering* in others. The possibility of this will be seen from the Figure. Here the ice, which is moving from left to right, is sliding over the rocky floor between A and B, and adhering to it from B to C. Between

[1] Geol. Mag., Dec. IV, Vol. IV, pp. 388–397.

A and B the velocity of sliding is v_3, whereas between B and C it is *nil*. The stream lines v_1 to v_6 show roughly the velocities along various planes in the glacier. It is clear that the ice before reaching B must be greatly compressed in the line of motion, and must eventually spread over the adherent portions, carrying the boulders, etc., up into the mass of ice as shown in the Figure.



That the ice may freeze firmly to the floor upon which it rests and drag up and carry along with it the rocky masses thus displaced, I have shown is a reasonable deduction on theoretical grounds, and it is interesting to find that the adhesion of the glacier to its floor in places will also account for the incorporation, in its lower portions, of boulders, etc.

NOTICES OF MEMOIRS.

I.—The Comparative Value of Different Kinds of Fossils in determining Geological Age.[1] By Professor O. C. Marsh, Ph.D., LL.D.

MORE than twenty years ago, my attention was called to the subject of the difference between the value of fossil Plants, Invertebrates, and Vertebrates, as evidence of the geological age of the strata in which they were preserved. On the comparative value of these different groups of fossils then depended the solution of some grave problems in the geology of the Rocky Mountains. I therefore began a systematic investigation of the subject, and gave the results in an address before the American Association for the Advancement of Science in 1877.[2] I stated the case as follows :—

"The boundary-line between the Cretaceous and Tertiary in the region of the Rocky Mountains has been much in dispute during the last few years, mainly in consequence of the uncertain geological bearings of the fossil plants found near this horizon. The accompanying invertebrate fossils have thrown little light on the question, which is essentially whether the great Lignite series of the West is uppermost Cretaceous or lowest Eocene. The evidence of the numerous vertebrate remains is, in my judgment, decisive, and in favour of the former view.

[1] Abstract of communication made to Section C, British Association for the Advancement of Science, Bristol Meeting, September 9, 1898.

[2] American Journal of Science, vol. xiv (November, 1877), pp. 338–378.

"This brings up an important point in Palæontology, one to which my attention was drawn several years since; namely, the comparative value of different groups of fossils in marking geological time. In examining the subject with some care, I found that, for this purpose, plants, as their nature indicates, are unsatisfactory witnesses; that invertebrate animals are much better; and that vertebrates afford the most reliable evidence of climatic and other geological changes. The subdivisions of the latter group, moreover, and in fact all forms of animal life, are of value in this respect, mainly according to the perfection of their organization or zoological rank. Fishes, for example, are but slightly affected by changes that would destroy reptiles or birds, and the higher mammals succumb under influences that the lower forms pass through in safety. The more special applications of this general law, and its value in geology, will readily suggest themselves."

In the statement I have quoted, I had no intention of reflecting in the slightest degree on the work of the conscientious palæobotanists who had endeavoured to solve the problem with the best means at their command. I merely meant to suggest that the means then at their command were not adequate to the solution.

It so happened that one of the most renowned of European botanists, Sir Joseph Hooker, was then in America, and to him I personally submitted the question as to the value of fossil plants as witnesses in determining the geological age of formations. The answer he made fully confirmed the conclusions I had stated in my address. Quoting from that, in his next annual address as President of the Royal Society, he added his own views on the same question.[1] His words of caution should be borne in mind by all who use fossil plants in determining questions of geological age.

The scientific investigation of fossil plants is an important branch of botany, however fragmentary the specimens may be. To attempt to make out the age of formations by the use of such material alone is too often labour lost, and must necessarily be so. As a faithful pupil of Goeppert, one of the fathers of fossil botany, I may perhaps be allowed to say this, especially as it was from his instruction that I first learned to doubt the value of fossil plants as indices of the past history of the world. Such specimens may indeed aid in marking the continuity of a particular stratum or horizon, but without the reinforcement of higher forms of life can do little to determine the age.

The evidence of detached fossil leaves and other fragments of foliage that may have been carried hundreds of miles by wind or stream, or swept down to the sea-level from the lofty mountains where they grew, should have but little weight in determining the age of the special strata in which they are imbedded, and failure to recognize this fact has led to many erroneous opinions in regard to geological time. There are, however, fossil plants that are more reliable witnesses as to the period in which they lived. Those found

[1] Proceedings of the Royal Society of London, vol. xxvi (1887), pp. 441–3.

on the spot where they grew, with their most characteristic parts preserved, may furnish important evidence as to their own nature and geological age. Characteristic examples are found among the plants of the Coal-measures, in the Cycads of Mesozoic strata, and in the fossil forests of Tertiary and more recent deposits.

The value of all fossils as evidence of geological age depends mainly upon their degree of *specialization*. In the Invertebrates, for instance, a Linguloid shell from the Cambrian has reached a definite point of development from some earlier ancestor. One from the Silurian or the Devonian, or even later formations, however, shows little advance. Even the recent forms of the same group have no distinctive characters sufficiently important to mark geological horizons.

If we take the Ammonites as another example from the invertebrates, the case is totally different. From the earliest appearance of this family, the members have been constantly changing, developing new genera and species, each admirably adapted to mark definite zones or horizons, and already used extensively for that purpose.

The Trilobites offer another example of a group of invertebrates ever subject to modification, from the earliest known forms in the Cambrian to the last survivors in the Permian. They, too, are thus especially fitted to aid the geologist, as each has distinctive features, and an abiding place of its own in geological time.

The above examples are all marine forms, and from their abundance, wide distribution both in time and space, are among the best of all witnesses in marking the succession and duration of changes in geological history.

If we turn now to the fresh-water Mollusca, we find among them little evidence of change from the Palæozoic forms to those still living, and can therefore expect little assistance from them in noting the succeeding periods during their life-history.

Among the fossil Vertebrates the same law as to specialization holds good. The value of particular groups as witnesses of geological changes depends largely on their own susceptibility to change, and this is equally true of single genera and species. There are, indeed, some primitive vertebrates, especially among the Fishes, that appear to have changed little during their geological life. The genus *Lepidosteus* is a good illustration, and hence it is of limited value as evidence of what has taken place during its known geological history. Other fishes, however, are much better witnesses of the past.

The Reptiles as a class offer still better evidence of geological changes, and in many instances may be used to advantage in marking horizons. The great subclass of Dinosaurs, from their beginning in the Triassic, show marked changes of development throughout the whole of Mesozoic time. During the Cretaceous, highly specialized forms made their appearance, and at the close of this period, when all became extinct, the last survivors were the strangest of all, reminding one, in their bizarre forms, of the last

stages of the Ammonites, their cotemporaries. The Crocodiles, too, show great changes during Mesozoic time, and are thus of much value in determining geological horizons. So, also, are the Pterodactyles and many other extinct reptiles, each according to the degree of specialization attained.

The Mammals, however, are by far the most important class for marking geological time, as their changes and the high degree of their specialization furnish the particular characters that are most useful to the geologist in distinguishing definite zones, and the more limited divisions of the strata containing their remains. The few mammals known from the Trias are so peculiar that they can only give us hints of what mammalian life then was, but in the Jurassic the many forms now known offer important testimony as to the different horizons in which their remains are found. This is true also of the known mammals from the Cretaceous; all are of special value as witnesses of the past.

During Tertiary time, however, the enormous development of the class of mammals, their rapid variations, and, most important of all, the highly specialized characters they develop, offer by far the best evidence of even the smaller changes of climate and environment that mark their life-history throughout. The ungulates alone will answer the present purpose as an illustration, and even one group, the horses, will make clear the point I wish to bring before you.

Near the base of the Eocene the genus *Eohippus* is found, representing the oldest known member of the horse tribe. Higher up in the Eocene *Orohippus* occurs, and still higher comes *Epihippus*, near the top of the Eocene. Again, through the Miocene more genera of horses, *Mesohippus*, *Miohippus*, and others, follow in succession; and the line still continues in the Pliocene, when the modern genus *Equus* makes it appearance. Throughout this entire series definite horizons may be marked by the genera, and even by the species of these equine mammals, as there is a change from one stage to the other, both in the teeth and feet, so that every experienced palæontologist can distinguish even fragments of these remains, and thus identify the zones in which they occur.

This is true of every group of mammals, although not to an equal extent, so that in this class we have beyond question the best means of identifying the age of Tertiary strata by their fossil remains.

I have thus briefly pointed out some of the evidence on which a decision may be reached as to the value of the different kinds of fossils, Plants, Invertebrates, and Vertebrates, in determining the relative age of strata. All evidence of this kind is of value, but it is the comparative value of each group that is the important point I wish to emphasize, and I have brought the matter before this Section of the Association in the hope that a better understanding on this question may be reached among geologists in the interest of the science to which we are all devoted.

II.—Further Exploration of the Ty Newydd Cave, Tremeirchion, North Wales. By Rev. G. C. H. Pollen, S.J., F.G.S.

In a paper read before the Geological Society on December 15, 1897,[1] the author gave the results of an exploration of 60 feet from the old quarry. The work has now been extended to 150 feet in this direction. In the upper portion a stalagmite floor has been found *in sitû*, completely sealing up the local gravels. Over this were found five feet of clay with broken limestone, which is all that is left to represent the strata in which the former roof of the cave was situated. The whole is now overlain with boulder-clay, containing many specimens of northern and western drift, with striated stones of more local origin. No trace of erratics or of glaciated stones have been found in the lower cave materials.

The cave has also been traced for 55 feet across the floor of the quarry where it re-enters the rock, running in the direction of the gully which separates it from the Ffynnon Beuno and Cae Gwyn caves. In the lowest gravel of this part a water-worn fragment of the molar of *Equus* was found. The following succession seems to be established for the contents of the cave:—

(*a*) Cave nearly filled by torrents with local gravel containing water-worn fragments of mammalian teeth.

(*b*) Formation of stalagmite floor.

(*c*) Last few yards of floor broken up and redeposited further down the cave by floods, which completely filled lower portion with sand and clay.

(*d*) Denudation of rock above, destroying roof of upper portion and depositing limestone débris on floor.

(*e*) Introduction of striated stones and northern and western erratics, which are deposited as one bed over the hillside.

III.—On the Exploration of Two Caves at Uphill, Weston-super-Mare, containing Remains of Pleistocene Mammalia. By the late Edward Wilson, F.G.S.[2]

(Communicated by Herbert Bolton, F.R.S.E.)

Quarrying operations now proceeding in the Carboniferous Limestone near the old parish church of Uphill have led to the discovery of two caves.

The caves are about half-way up the face of the quarry, which is 100 feet in height. The floor of each cave is covered with a deposit which varies from one to two feet in thickness.

A typical section of the upper cave deposits is as follows:—

	ft.	in.
1. Deep purplish-red, soft, sandy Marl, containing blocks of Limestone	4	0
2. Greenish-yellow, soft, sandy Marl	1	2
3. Greenish-drab argillaceous Sandstone	5	6
4. Limestone floor.		

[1] Quart. Journ. Geol. Soc., February, 1898, pp. 119–134, pl. viii.

[2] Read before Section C (Geology), British Association, Bristol Meeting, September, 1898.

The Green Marl (No. 3) for a varying thickness in different parts of the cave becomes brecciated and occasionally tufaceous.

The animal remains are contained in this bed, and consist chiefly of the teeth and jaws of hyæna, with gnawed and ungnawed bones of horse, mammoth, cave bear, fox, etc.

The lower of the two caves is partly filled with a deposit of coarse rubble, and has yielded remains of hyæna, rhinoceros, and the teeth and jaws of small carnivora and rodents, together with worked flints, and a number of rounded stones supposed to have been used as pot-boilers. The rubble deposit has evidently undergone a certain amount of displacement, so that it is by no means certain if the remains contained in it are contemporaneous.

IV.—Further Exploration of the Fermanagh Caves.[1] By Thomas Plunkett, Enniskillen.

THE original report was read by me at Dublin in 1878, and I then stated that after the exploration of F cave the work would be suspended, as it seemed probable that none of the caves in this district would yield bones of extinct mammalia.

I spent three summers exploring the caverns which penetrate the Carboniferous Limestone hills in Fermanagh, in which I found flint implements, bone, bronze, and iron pins, a large cinerary urn inverted over burnt human bones, human skulls, ancient hearths, etc., also quantities of the bones of the wild horse, red deer, long-snouted pig, ox, and remains of other animals not extinct. Having explored a number of caves in this county previous to my reading the report referred to above, I came to the conclusion that remains of extinct mammalia were not likely to be found in this locality. Now, on the contrary, I am glad to be in a position to report that I have been fortunate in finding an entire cranium of what I believe to be the great cave bear (*Ursus spelæus*) in one of the Knockmore caverns, which penetrates a cliff not far from the caverns I formerly explored, and is a narrow cleft with vertical sides. The height of the cave is about 40 feet and length 90 feet. When standing at the extreme end of this cleft-cavern one may observe near the top of one of the sides an opening which is evidently the end of a horizontal cave which runs at right angles into the cave in question; a good deal of débris has been during heavy rains washed out of the higher cave down into the lower one; in this débris, the cave bear's head was found, and I have no doubt that, when explored, the higher cave will yield more remains of the skeleton of the bear and possibly other extinct animals.

I have commenced excavations on the top of the rock, and hope to find the upper or horizontal cavern (which cannot be reached from the narrow cave below), which formerly must have had an opening out to the surface of the ground, and probably has been filled up level with the surface for the protection of cattle.

[1] Read before Section C (Geology), British Association, Bristol Meeting, September, 1898. See also earlier Report, 1878, pp. 183–185.

I thought it well to place this find in Fermanagh upon record in the proceedings of the British Association, and I shall be happy to report to the Association next year the results of the cave-digging which I am carrying on here at present.

REVIEWS.

I.—A Text-Book of Mineralogy, with an Extended Treatise on Crystallography and Physical Mineralogy. By Edward Salisbury Dana. New Edition, entirely rewritten and enlarged. 8vo; pp. 593, with nearly 1,000 Figures and a Coloured Plate. (New York: John Wiley & Sons, 1898.)

BY the irony of Fate the author of this treatise, Mr. E. S. Dana, though an experienced mineralogist, is a University Professor, not of Mineralogy, but of Physics; those who have been his pupils report him to be an ideal teacher of that branch of knowledge: further, Mr. Dana prepared for press the last edition (1892) of his father's well-known "System of Mineralogy," a book which is in constant use by mineralogists throughout the world. An excellent teacher and closely associated with Mineralogy as a living science, Mr. Dana was thus particularly qualified to furnish the Students of Minerals with a good text-book of their subject, and he has done so.

The work was first issued twenty-one years ago: the author has now rewritten it with the results of recent researches in mind. Part I (144 pages) deals with Crystallography in a practical way, demanding from the student only the elements of mathematical science. The subject is treated from the point of view of Symmetry, and the thirty-two classes of symmetry are briefly but clearly explained; the name assigned to each of the prominent classes being taken from some mineral species, of which the crystals present good illustrations of the class of symmetry. The facial symbols are those of Miller, and stereographic projection is made extensive use of. Part II (94 pages) treats of Physical Mineralogy in a similarly elementary way, and necessarily deals for the most part with the characters which depend upon Light, and with the modes of their determination. "Axes of optical elasticity" are dropped, and the "Indicatrix" is explained and made use of in the discussion of doubly-refracting crystals. Part III, Chemical Mineralogy, is compressed into 30 pages, and is limited to the explanation of the general principles of Chemistry and of the modes of chemical determination of minerals. The last Part, Descriptive Mineralogy, extending to 225 pages, is not susceptible of much variation of treatment, but is accurate and brought up well to date. The book is plentifully illustrated throughout.

We may assume that so completely changed an Edition is evidence of the recovery of the author from the shattered health to which he had been brought by the years of toil required by the preparation of the last edition of the "System of Mineralogy";

we take this opportunity of congratulating both Professor Dana and the Science to which he so largely devotes his energy on this improved position.

II.—First Lessons in Modern Geology. By the late Professor A. H. Green, M.A., F.R.S. Edited by J. F. Blake, M.A. pp. vi and 212, with 42 woodcuts. (Oxford : Clarendon Press, 1898. Price 3*s.* 6*d.*)

GEOLOGICAL handbooks intended for the use of beginners take various lines of teaching. Some seem to aim at presenting an abstract of the contents of the more or less complete treatises on the principles, elements, and conclusions of the science. Others, taking a separate line of thought, try to lead the tyro through strata and rock-masses, cliffs and escarpments, valleys and mountains, to the heights or levels hoped for. Of others we may say that a book-knowledge of some branches of the science, laboriously fashioned into a more or less readable category of statements, with borrowed tables and oft-used woodcuts, is offered to the public. There are, however, better guidebooks than such as these for beginners, and an example of this sort is noticed in the Geological Magazine for November.

Still, there is another kind of first-geology book, which adopts a familiar style with the popular and almost homely language of a well-informed and well-qualified teacher. Such a primer was foreshadowed long ago by dialogues with children, in parlour, field, and study. These formal, old-fashioned, didactic, and sometimes pedantic, catechismal or conversational books, intended for the young, are extinct. Nowadays the subject-matters of both questions and answers, taken in their simplest form, run on in paragraphs or chapters, successively as one suggests another, or as they are systematically planned to occur.

In the "First Lessons in Modern Geology," we have evidence that the teacher is decidedly conversant with the latest descriptions and explanations of geological facts, and that he possesses the power of illustrating his statements by references to analogous affairs and things of current life and common observation. He moreover freely offers explanations of the nature and conditions of the earth's surface and materials as far as the as yet unschooled mind of the tyro can comprehend them.

Those to whom a simple primer and some first lessons in geology are useful may be — either (1) young folk and school-children with an aptitude to observe and a wish to inquire about stones and other natural objects in roads and quarries, or in public museums and collections at home; or (2) more advanced scholars who have to be prepared for professions in which geology is more or less important. Led on by homely remarks on common materials, the student is taught in clear every-day language how to examine them with precision, and step by step to know their aspects, characters, and composition. Thus prepared he is taken to observe

quarries, hill-sides, and other places where sections of various rock-masses are, by the well-educated teacher, made to indicate the how and the why of their origin, changes, and present condition. Lesson VII supplies a good example of the line of thoughtful inquiry into the succession of events which go to make up the long geological history of the changes which have taken place during the building-up of the Earth's surface. We are reminded here and there that for some of the great problems in the Earth's history explanations cannot be given in the *first* lessons in geology, but they must be reserved by the student till a later stage in his progress.

That these are lessons in *modern* geology Professor Green's teaching gives full evidence throughout, especially on the subject of thrust-faults, schistose rocks due to crush, transverse valleys, origin of flints in chalk, cautious reference to the origin of Boulder-clay, etc.

The printer's type in this book is good and clean. Of the forty-two illustrations nineteen are new, very useful, and well printed; of the others several are from Professor Green's larger work. We heartily recommend this excellent and well-written primer or handbook of "First Lessons" for home use in intelligent families, and to educational establishments as a trustworthy early guide in the study of geology.

III.—Supplement to the Geology of the Neighbourhoods of Flint, Mold, and Ruthin. By A. Strahan. Memoirs of the Geological Survey. 8vo; pp. vii. (London, 1898. Price 2*d.*)

THE object of this Supplement is to record a series of borings which have been put down in the reclaimed portion of the estuary of the Dee. They prove the existence of Upper Coal-measures, which nowhere appear at the surface, and which were not previously known to be present in Flintshire or West Cheshire. The discovery of these strata is of importance, as they may underlie much or all of the Cheshire Trias; they are not productive, and consequently they would have to be penetrated before the productive Middle Coal-measures could be reached.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 9, 1898.—W. Whitaker, B.A., F.R.S., President, in the Chair.

The President drew the attention of the Fellows to the new Geological Survey Index Map of England and Wales, which had been hung upon the walls of the meeting-room during the recess.

Mr. Bauerman, in exhibiting a map of the Gellivara iron-ore deposits, pointed out that these constitute a chain some five miles

in length, and are made up essentially of magnetite interlaminated with apatite. In addition to these mines, which are far north of the Arctic Circle (70 miles N. and 120 miles W. of the Gulf of Bothnia), he had had an opportunity of visiting the deposits of Kirunavara, 100 miles still farther north; here the rocks are of a slaty character, and the magnetite is included in felsite-porphyry. The Gellivara ores are contemporaneous with the surrounding rock, while the Kirunavara ores appear to have been introduced at a later period. Mr. Bauerman exhibited specimens from both districts, and drew attention to the phenomena of polishing by wind-action, etc.

The following communications were read:—

1. "On the Palæozoic Radiolarian Rocks of New South Wales." By Professor T. W. Edgeworth David, B.A., F.G.S., and E. F. Pittman, Esq., Assoc. R.S.M., Government Geologist, New South Wales.

The first evidence of the presence of radiolaria in the rocks of New South Wales was obtained by Professor David in 1895, as the result of a microscopic examination of some red jaspers from different areas. Further research by the same author was stimulated and guided by seeing the radiolarian rocks recently discovered in Mullion Island, Cornwall, and in the Culm districts of Devonshire, during a visit to England in 1896; and on his return to Sydney he recognized the existence of a series of cherts, lydites, and siliceous limestones containing radiolaria in four distinct areas. A brief preliminary account of these rocks was communicated to the Linnean Society of New South Wales, and specimens were forwarded to Dr. G. J. Hinde for determination of the radiolaria. Subsequently, in conjunction with Mr. Pittman, a detailed examination of the rocks in the field was carried out, and the results are given in the present paper. In this final investigation it was ascertained that not only in the cherts and siliceous limestones, but also in the jointed claystones which form the prevalent sedimentary rocks of the Tamworth district, radiolaria were distributed in vast numbers.

The three chief areas of radiolarian rocks in New South Wales are Bingara, Barraba, and Tamworth, situated in the New England District, between 180 and 270 miles north of Sydney. Bingara, the farthest locality, is 30 miles north of Barraba; and this latter is 60 miles north of Tamworth. The character of the rocks in these localities tends to show that they belong to the same series; and in this case its extension from south to north is about 85 miles.

The fourth area of radiolarian rocks is at the well-known Jenolan Caves, about 67 miles due west of Sydney and about 200 miles south-by-west of Tamworth. It is probable that the Jenolan rocks may be on a somewhat different, perhaps lower, horizon than those of the northern district.

At Bingara and Barraba the radiolarian rocks consist of red jaspers and fine-grained jointed claystones, accompanied by thick coral-limestones and numerous beds of interstratified tufaceous materials.

The radiolaria occur as casts in chalcedony in the jaspers and claystones. The rocks dip at a high angle. No macroscopic fossils are known with certainty from these districts.

In the Jenolan Cave district the radiolarian rocks consist of black cherts and clay-shales overlying the Cave Coral Limestone, and of greenish-grey shales underlying this rock. The series is traversed by felsitic dykes, and the hardness of the cherts is attributed to silica derived from the acidic dykes, rather than to that derived from the tests of the siliceous organisms.

It is at Tamworth that the radiolarian rocks are developed on a grand scale; their measured thickness amounts to 9,267 feet, after allowing for an immense fault, and neither upward nor downward limit is shown. The rocks consist of jointed claystones, black cherts, lenticular siliceous radiolarian limestones, and coral-limestones. Numerous beds of submarine tuff also occur. The claystones are largely formed of radiolaria. In certain beds of the claystones, and in some of the tuffs as well, impressions of *Lepidodendron australe* are not uncommon; and beds of radiolarian limestone occur in close proximity to the beds with these plant-remains, and radiolaria moreover abound even in the same rock with the *Lepidodendron* impressions.

At the eastern end of the Tamworth section, and also near the westerly portion, there are limestones containing corals, which have been determined by Mr. R. Etheridge, jun. They are similar to those of the Burdekin Limestones of Queensland which belong to the Middle Devonian, and the radiolarian rocks are thus shown to belong to this period.

Analyses of the radiolarian chert, cherty shale, shale, and siliceous limestone prepared by Mr. J. C. H. Mingaye, F.C.S., are given; and from these it appears that, while the amount of silica in the chert and shale ranges between 68 and 91 per cent., there is only 18 per cent. in the siliceous limestone.

Descriptions of numerous micro-sections, both of the sedimentary and of the tufaceous rocks, are appended, and in their conclusions the authors point to the remarkably fine-grained character of the materials forming the base of the radiolarian cherts, jaspers, and shales, the constituent particles not being more than 0·05–0·025 mm. ($\frac{1}{500}$ to $\frac{1}{1000}$ inch) in diameter. They are of opinion that the radiolaria were deposited in clear sea-water, which, though sufficiently far from land to be beyond the reach of any but the finest sediment, was nevertheless probably not of very considerable depth.

2. "On the Radiolaria in the Devonian Rocks of New South Wales." By G. J. Hinde, Ph.D., F.R.S., F.G.S.

Hand-specimens of the various radiolarian rocks discovered by Messrs. David and Pittman in New South Wales were forwarded to the author, and from them numerous microscopic sections were prepared. In the chert and jasper rocks of the Jenolan, Bingara, and Tamworth districts, the radiolaria were for the most part in the condition of casts filled with chalcedonic silica and without structure,

so that their generic characters could not be determined. Also in the claystones, the radiolaria were but poorly shown in sections, though the structure could be seen in specimens weathered out naturally on the surface of the rock. But in the siliceous limestones and in the volcanic tuffs the radiolaria were embedded in, and infiltrated with calcite, and by careful etching of thin sections of the rock, the lime was eliminated and the organisms were shown very distinctly. The rock then appeared as a confused mass of entire and fragmentary radiolaria and minute débris of their spines and latticed tests. The silica of these forms is for the most part still in its colloid condition; in some, however, it has been replaced by a dark mineral.

Fifty-four species belonging to 29 genera have been determined and figured; all the species and four genera are regarded as new; excepting a few primitive types of *Nassellaria*, the forms belong to the *Spumellaria*. The large majority may be included in the *Sphæroidea* and *Prunoidea* with medullary tests and radial spines. They do not show any near relationship to the radiolaria described from Devonian rocks in Europe, but in some features they resemble the radiolarian faunas of Ordovician age in the South of Scotland, Cornwall, and Cabrières, Languedoc.

No other fossils beyond a few simple sponge-spicules and, on two or three horizons, some fragmentary impressions of *Lepidodendron australe*, have been found in association with the radiolaria.

These New South Wales radiolarian deposits are by far the most extensive of any hitherto known, and they are remarkable, not only for their great thickness, but also for the manner in which the radiolaria are preserved in the limestones, tuffs, and claystones.

MISCELLANEOUS.

Coal in Western Australia.—The Agent-General for Western Australia has received the following cablegram, dated Perth, W.A., October 20: "Sir Frederick M'Coy reports, regarding further coal specimens and fossils from Collie Coalfield, he is now able to state deposit is exact geological age as great coalfields Newcastle, New South Wales. Coal specimens from bore cores quite equal to best coals Newcastle district. He considers it magnificent and valuable discovery, and says fossils are *Glossopteris Browniana*."—*Morning Post*, October 22, 1898.

West Australian Gold.—The output of gold in Western Australia for October amounted to 115,376 oz., valued at £438,428. This is by far the greatest monthly output in the history of the colony. During the ten months of the year ending October 31 the gold exported from the colony has amounted to 841,625 oz., valued at £3,198,176, as compared with 526,736 oz., valued at £2,001,600, in the corresponding period of last year.—*Morning Post*, November 2, 1898.

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